POWER

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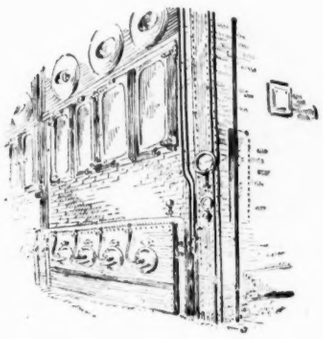
Looking Out For Number One

By RUFUS T. STROHM

Quite recently I called to see an old acquaintance, Dave McKee, who'd just put up a modern shop outfitted new from base to top; and when, in sauntering around, we reached the boiler room, I found no grimy, straining, sweating groups of stokers plying heavy scoops. The plant was just as neat and clean as any house I've ever seen.

Said Dave: "We're burning fuel oil because it saves a lot of toil like moving coal by cart or chute and getting ashes out, to boot. It's wholly free from dust and grit, there are no clinkers made by it, and if there comes an overload, the whirring engines are not slowed, because we set the burners wide and quickly have the steam supplied."

"I'll grant you that you're apt to save both time and work," I said to Dave. "But all our coal fields with their store will last a thousand years and more, whereas our oil supply, you know, will end in twenty years or so, and when it's gone, what will there be to lubricate machinery? To save your everlasting soul you can't oil shafts and guides with coal."



"Perhaps you're right," said Dave to me, and smiled quite condescendingly. "But I should worry and grow gray with troubles of a future day. I'll be beneath the sod, no doubt, before the oil supply runs out, and those who follow me must hoe their own partic'lar kind of row. I'm doing what a wise man would—I'm getting while the getting's good."

Thank God, the men of David's stripe are not as yet the common type!

Non-Condensing Turbine Plant of the Western Felt Works

Efficient Non-Condensing Turbine Plant in Which Exhaust Steam Is Utilized for Process Work and for Heating. The Plant Has a Capacity of 800 Kilowatts and Is Attractively Finished and Well Equipped with Labor-Saving Devices

AT THE close of the last year the Western Felt Works, of Chicago, completed a trim little power plant, which should prove unusually efficient and economical to operate. This company has been established 21 years and is the largest independent felt mill in the country.

Formerly, the steam and power needs of the company were met by a couple of water-tube boilers, a Corliss engine furnishing mechanical power, and purchased current from the Sanitary District. In the early months of 1920 considerable alterations, extensions and new buildings were contemplated so that a new plant was needed for the enlarged works. Some of the equipment of the older plant was retained, such as the two boilers; a larger boiler was added and a new engine house built. In this department were installed two non-condensing turbo-generators to meet the electrical load and at the same time supply the large quantities of exhaust steam needed for drying and for heating. With the exception of the heating the other demands for exhaust steam are continuous throughout the year. The electrical demand is such that all exhaust steam should be utilized in the winter months and supplemented somewhat with live steam, particularly in the finishing room, where a pressure of about 60 lb. is required to provide the temperature desired. In the summer there will be some excess of exhaust steam, but the loss anticipated will be small, so that the plant throughout the year should show an exceptionally high average economy. Dividing the operating costs proportionately for the various uses of the steam will leave a very small balance to charge against the generation of electric power.

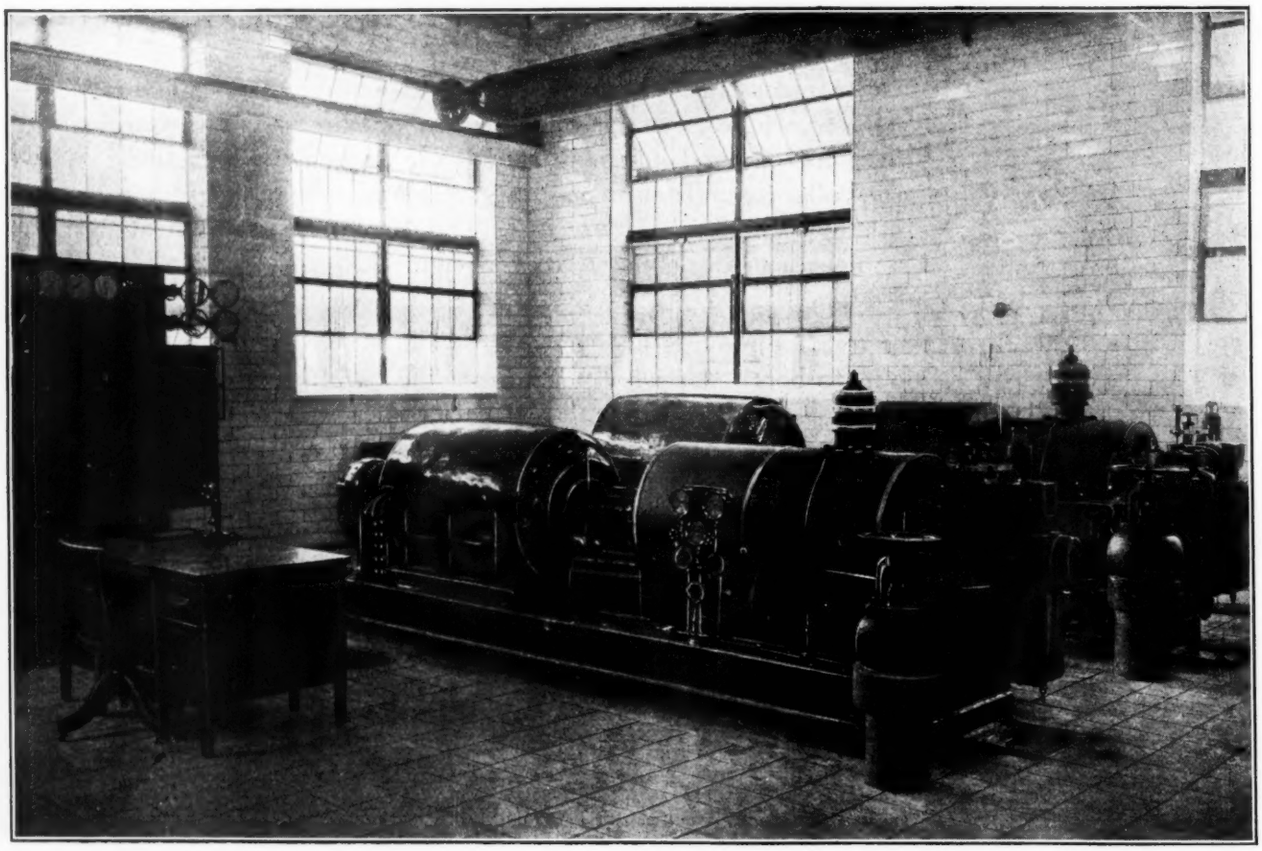


FIG. 1. NON-CONDENSING TURBO-GENERATORS AT THE PLANT OF THE WESTERN FELT WORKS

The boiler room is ideally arranged for efficient operation. Good light and ventilation are provided by side windows and a roof ventilator extending the full length of the boiler room immediately over the boilers. The coal and ash handling is done mechanically, so that but little manual labor is required.

Self-dumping coal cars are brought to the unloading position on elevated tracks. The coal is dropped into a

large hopper, passes through a coal crusher and is conveyed to inverted-pyramid shaped coal bunkers. From these bunkers the coal is dropped into a track-suspended lorry equipped with coal-weighing scales, which is moved by means of chain-driven gears to the several stoker hoppers.

In the boiler room the present equipment consists of a new Stirling boiler having 3,940 sq.ft. of steam-making surface and the two older boilers which have been retained—one of the same type as the new one with 3,000 sq.ft. of steam-making surface, and the other a horizontal water-tube boiler containing one-half this surface. It is the intention to rebuild the settings of these two units and in the larger of the two install a superheater. In the smaller boiler nothing but the setting will be remodeled as it is being held for night and emergency service and eventually will be replaced by a larger boiler. All three boilers are equipped with chain grates having the standard amount of active grate area.

The two older stokers were equipped for individual motor drive. The location of the motor on the side of the stoker hopper proved undesirable, as the machine would clog up from the dust and dirt and give a great deal of trouble. Consequently, an overhead lineshaft was provided to drive the three stokers. This shaft is now driven by a small vertical engine, and a motor will be installed for night operation or emergency use when only low-pressure steam is being generated. From the lineshaft quarter-turn belts to the stoker countershaft do the driving.

The ashes are handled by a steam-jet conveyor system that is equipped with two ½-in. nozzles at the bottom and top elbows respectively and discharging into an overhead tank from which the contents are delivered into the railway coal cars.

A brick stack, 7 ft. in diameter at the top and 175 ft. high, serves the boilers. The boiler-feed pumps and the vacuum pumps for the heating system are of the reciprocating type, the former being duplex pumps, one 8 and 5 x 12 in., and the other 9 and 6 x 12 in. Simple pumps, one 10 and 14 x 18 in. and the other 6 and 8 x 12 in., draw the vacuum on the heating system. The returns are collected in a receiving tank 7 ft. long and 3 ft. 6 in. in diameter. In this tank makeup water is added as required. The feed water is then passed to a large open heater, filter and purifier of sufficient capacity to serve the three boilers. There is also a large closed heater to supply hot water for industrial use. It is equipped with coils taking exhaust steam in sufficient quantity to maintain a temperature of 140 to 150 deg., under the control of a temperature regulator. For blowing out textile mechinery and motors the plant is now equipped with a locomotive-type air compressor. This is to be replaced by a steam-driven unit of the flywheel type having capacity to deliver about 100 cu.ft. of air per minute, the air pressure to be 100 lb. per square inch and the operating speed 125 revolutions per minute.

To house the turbo-generators and the switchboard a new building having a floor area of approximately 36 x 38 ft. and a ceiling height of 16 ft. was erected. The exterior is of common brick with ½-in. recesses and red mortar, giving the edges of the brick a delicate stain. On the interior the walls are of white enameled brick. The ceiling is paneled and finished in smooth white. The floor is of concrete marked out into squares. There is abundant glass area in the side walls,

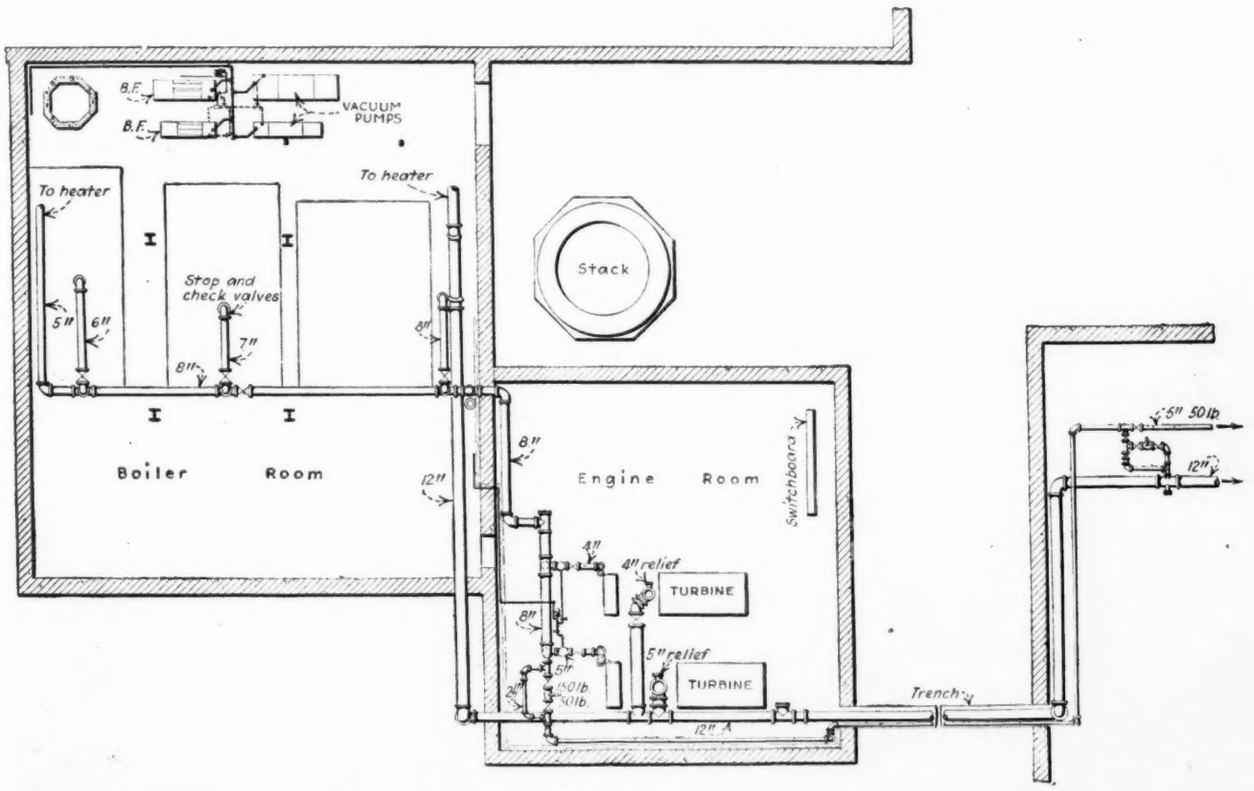


FIG. 2. GENERAL PLAN OF THE POWER PLANT AT THE WESTERN FELT WORKS SHOWING THE MAIN-UNITS AND PIPING LAYOUT

and the metal window frames as well as the metal doors of the building and the overhead crane, are painted a mottled green, technically known as a verde antique finish. All this in combination with the neatly painted generating units gives the room an attractive appearance. The generators are painted an elephant gray and the turbines jet black, both being trimmed in green and affording a pleasing contrast with the brass gages and connecting tubes mounted on the bases of the machines. The switchboard is black slate and is equipped with the usual instruments, including a voltage regulator, a synchronoscope, polyphase watt-hour meters, ammeters and voltmeters. Inclosed fuses for the feeder circuits are mounted on the front of the board. Fig. 4 shows the arrangement of the back of the board and

Air for cooling the larger generator is drawn from outside the building through a 30-mesh copper screen and 15 muslin bags 12 in. in diameter by 4 ft. long secured to a galvanized iron framework. The air, thoroughly cleaned, passes on through a duct to the generator and is discharged from the bottom of the machine into the basement. The smaller generator draws the cooling air from the turbine room and also discharges to the basement through the base of the generator. The amount of air circulated to cool the larger machine is 2,500 cu.ft. per min., while for the smaller generator four-fifths of this quantity is considered ample.

Lubricating oil in the reservoir in the turbine base is cooled by a water coil. For gland sealing distilled water is used. From a reservoir in the basement this

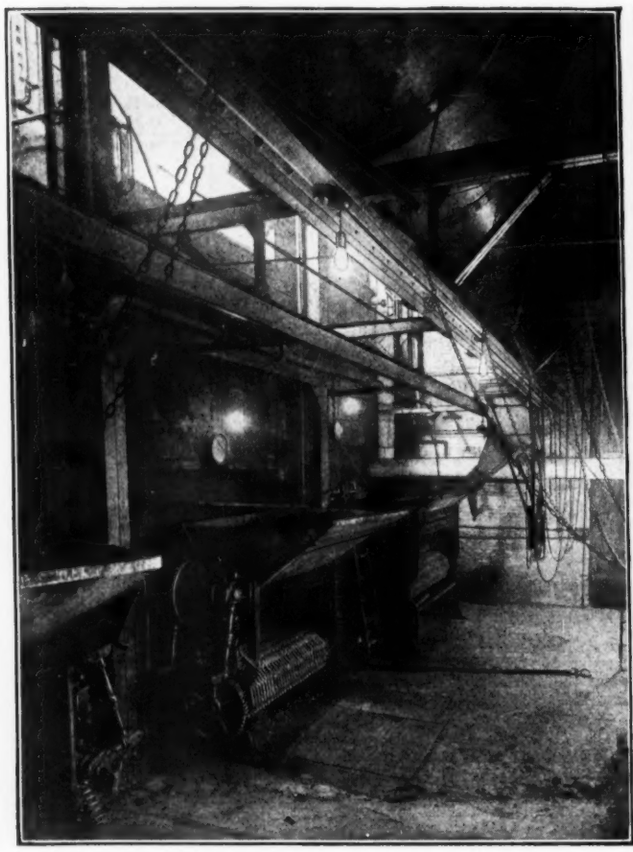


FIG. 3. VIEW OF THE BOILER FRONTS

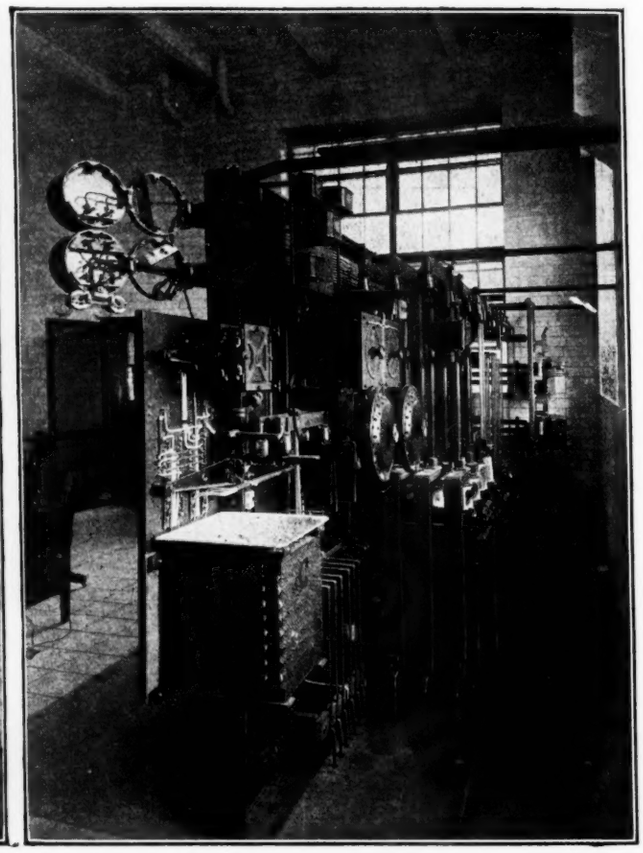


FIG. 4. REAR VIEW OF THE SWITCHBOARD

Fig. 1 shows the generating units and a portion of the front of the switchboard.

Capacities of the two turbo-generators are 500 kw. and 300 kw. at 80 per cent power factor, respectively. The speed of these machines is 3,600 r.p.m., and three-phase 60-cycle current is generated at 220 volts. The exciters are mounted on the ends of the generator shafts. Owing to the fact that practically all the exhaust steam is utilized, the water rates are not of great importance, but the guarantees are as follows when the machines are supplied with steam at 150 lb. pressure and 100 deg. superheat: For the 500-kw. machine at one-half load, or 250 kw., 46 lb. per kw.-hr.; for three-quarters load, 40 lb., and for the full load of 500 kw., 37.1 lb. per kw.-hr. For the smaller machine the water rates are 53.9, 45.1 and 40.9 lb. per kw.-hr., respectively.

water is circulated continuously by a small motor-driven pump and is thus used over and over again. A cooling coil in the reservoir keeps down the temperature. City water first extracts the heat from the lubricating oil and then from the gland water before it is passed on to the feed-water heater.

Referring again to the switchboard, the generator switches are of the oil-break type with overload tripping coils. An additional overload release switch provides emergency and night service to the common busbars. The generating plant is operated only during the daytime. Current from the Sanitary District will still be used for night lighting and emergency power such as for the fire pump and the elevators. During the winter nights one of the boilers will be kept in operation, but only at low pressure in order to keep the building sufficiently warm.

All feeder and generator cables emerge from the basement through slate floor slabs and connect to the busbars within 6 in. of the floor line. The 110-volt lighting circuits are obtained by bridging each of the three phases with balance coils and connecting the neutral to a central tap. The connected load is 1,150 hp. for 88 motors and 50 kw. in lights, but the diversity factor will probably permit the smaller generator to handle the actual demand. As new buildings are added, however, the load will increase so that the larger generator will be required and probably at peak periods the two machines.

Basement Arrangement

Under the generating room the basement is conveniently arranged, being equipped with shower baths, toilets, etc. Its real function, however, is to give an outlet for the cables, steam pipes and air ducts to their respective places of service and conceal them from view on the main floor. The steam separators in the lines supplying the turbines and the generator rheostats are located here, and also the distributing cabinets for the light and power service to the power house and boiler room. All feeder cables leave the power house by way of the basement as do the exhaust steam pipes and also the boiler line which supplies live steam to the works.

In discussing electrical distribution, it should be stated that the main buildings are continuous and divided into sections. These sections answer to the fire underwriter's requirements for cutoff walls, stair vestibules and self-closing doors. The entire plant is equipped with automatic sprinklers. The interiors of the buildings are in the main of mill construction, there being, however, a few sections of concrete. The buildings are chiefly three stories in height and without basements, having a total floor area of approximately 243,500 sq.ft.

In the early months of 1920 considerable alterations, extensions and new building were contemplated. Plans for the new building had been made, but a definite and decisive layout for the alterations was not obtainable. It was decided to establish four principal points of distribution and to carry copper capacity direct from the service switch equal to 250 hp. at 220 volts to each one of these points. At this time the company was buying power from the Sanitary District and the decision to build a power plant had not been made. With this decision, and owing to developments in the way of increased motor connections, two additional 250-hp. centers were established, making six principal centers with an aggregate of 1,500 hp. To each of these centers and direct from its respective feeder switch on the power-house switchboard are carried three 1,000,000 circ.mil cables.

These principal centers were not intended to receive leads direct from the motors, but were designed to furnish service to sub-panels which were equipped with terminals suitable for motors of fractional horsepower up to 25 hp. For motors over 25 hp. it was intended to carry the leads direct to the principal centers, where they would find suitable terminals.

Immediately following the new power-plant decision some of the previous prevailing construction ideas had to be abandoned and an underground conduit system from the power house was planned. The details of construction of this underground system brought out some interesting points. The first consultation with the two chief supervising bodies of the city resulted in their refusal to permit the several conductors of an alternating-current circuit to be installed under separate lead sheaths. As the cable size was 1,000,000 circ.mil three of these under one lead sheath would require methods of handling entirely out of the ordinary. Consultation with the cable manufacturers brought out the information that cables of 500,000 circ.mil, three under the same lead sheath, had been made, but that it was rather special.

Fiber Conduits Selected

The relative merits of vitrified stone and fiber conduit were discussed with the decision in favor of fiber. It developed that 4-in. fiber was the largest standard size made and the three separately sheathed 1,000,000 circ.mil cables were drawn through 205 ft. of conduit and around three right-angle bends. A plan similar to the one described for the distribution of service for motors was carried out for the lighting circuits. The branch circuit lighting panels were liberally designed as to the number of circuit units per floor and building section.

Credit for the design is due Charles W. Brown, the consulting engineer. Mr. Brown was formerly with Armour & Co. and is widely known for his ability as an engineer and production expert. R. J. Watson is chief engineer of the power plant.

PRINCIPAL EQUIPMENT OF WESTERN FELT WORKS PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbines	Reaction	500 and 300 kw.	Main generating units	150 lb. pressure, 100 deg. superheat, 3,600 r.p.m.	Allis-Chalmers Mfg. Co.
2	Generators	Alternating-cur.	500 and 300 kw.	Main generating units	3 phase, 60 cycle, 240 volts, 3,600 r.p.m.	Allis-Chalmers Mfg. Co.
1	Crane	Travel., hand-op.	5 ton	Serves engine room		Whiting
1	Boiler	Stirling	3,940 sq.ft.	Generates steam	150 lb., 100 deg. superheat, natural draft	Babcock & Wilcox Co.
1	Boiler	Stirling	2,895 sq.ft.	Generates steam	150 lb., 100 deg. superheat, natural draft	Babcock & Wilcox Co.
1	Boiler	Horiz. water-tube	1,500 sq.ft.	Generates steam	150 lb. pressure, natural draft	Altman & Taylor
3	Chain grates	Traveling	80, 40 and 25 sq.ft.	Serve boilers	Engine- or motor-driven	Mekenzie
1	Stack	Brick	175 ft. high, 7 ft. diam.	Serves boilers		F. & B. Flasch Chimney Co.
1	Coal crusher	Double roll	14 in., 40 tons per hr.	Crush coal	Driven by 25 hp. motor	Weller Mfg. Co.
1	Conveyor	Apron conveyor	8 x 18 in.	Elevate coal to bunkers	Driven by 15 hp. motor	Weller Mfg. Co.
1	Weigh lorry	Traveling	½-ton	Weigh coal to boilers		Weller Mfg. Co.
1	Ash conveyor	Steam-jet	8-inch line	Removes ashes	Two ½-in. nozzles	C. W. Brown
2	Pumps	Duplex	8 x 5 x 12 in. 9 x 6 x 12 in.	Boiler-feed water	150 lb. steam	Dean Brothers
2	Pumps	Simplex	10 x 14 x 18 in. 6 x 8 x 12 in.	Vacuum pumps on heating system	150 lb. steam, 10-in. vacuum	Dean Brothers
1	Pump	Centrifugal	1-in.	Circulate gland seal water	Motor-driven	Economy Pump & Machinery Co.
1	Air compressor	Locomotive	8 x 9½ x 11 in.	Blowing out textile machines and motors	Steam-driven, 100 lb. air	Westinghouse
1	Heater	Open	36,000 lb. water per hr.	Heat boiler feed	Exhaust steam	Sims
1	Heater	Closed	66 in. x 18 ft.	Industrial and domestic hot water	Exhaust steam, water 150 deg.	Sims

Westinghouse Switchboard, Western Electric, Wagner, Howell and Lincoln motors; Jenkins cast-steel angle throttle valves on turbines; Crane steam valves, Pratt & Cady water valves, Cadman blowoff valves, Armstrong & Crane steam traps, Grinnell-Russell steam separators, Crane safety valves, Ashcroft gages, Diamond soot blowers, Graves water softening plant for industrial purposes, Mason & Boyleston steam regulating valves, Dayton-Dowd electric fire pump.

The Heat Pump in Theory and Practice

Comparisons of Costs of Coal and Electricity for Industrial Process Heating—Methods of Applying Heat in Industrial Processes—Theory of Heat Pump—With the Same Expenditure of Energy Twenty Times as Much Process Heating Can Be Done with the Heat Pump as by Using Electricity Direct

By FRITZ KRAUSS

THE "Heat Pump" is an apparatus by means of which mechanical work may be converted into heat. In this respect it is the contrary of a heat engine. It may seem inconsistent that any useful or economical effect could be derived from a contrivance that consumes the high-grade energy of mechanical work and furnishes instead the low-grade energy of heat, but this is just what the so-called heat pump does. But there are similar conversions in daily use. Heating by electricity, for instance, is one, the high-grade energy of the electric current being converted into heat; however, in most cases heating by electricity is expensive.

Inasmuch as every kilowatt-hour consumed develops approximately its full equivalent of 3,428 heat units, an electric heating appliance works without any appreciable loss. But the generation of one kilowatt-hour in a central station necessitates the consumption of about 1½ lb. of good coal under the boilers when operating under the best conditions. The heating value of one pound of coal being about 13,500 B.t.u., the total efficiency of the process is scarcely 17 per cent, or less than the performance of the worst kitchen fire.

Difficult for Electricity to Compete

As already mentioned, the equivalent of one kilowatt-hour is 3,428 heat units, while 1 lb. of coal furnishes 13,500 heat units. Therefore, on this basis, if electrical energy is to compete with coal or steam for heating purposes, the price of one kilowatt per hour would have to be one-fourth that of one pound of coal. It must be borne in mind, however, that the efficiency of steam boilers is far below that of an electrical heating apparatus, which on the average amounts to 95 per cent. If, under there circumstances, the efficiency of the boilers were as low as 60 per cent, the relative prices of one kilowatt-hour and one pound of coal would yet have to be as 1:2½. Perhaps this ratio might be obtained in some water-power station. For a steam-driven plant it would mean that 2½ kw.-hr. had to be generated with one pound of coal. This, of course, is out of the question. An ideal steam engine working with superheated steam of 650 deg. F. temperature and 200 lb. pressure, exhausted to a vacuum of 28 in. will produce one kilowatt-hour for 11,500 heat units contained in 8.5 lb. of steam. Taking the thermodynamic efficiency of an actual steam engine at 75 per cent and the efficiencies of the generators and boilers at 95 per cent and 80 per cent respectively, giving a total efficiency of 57 per cent for the complete generating plant, the heat consumed amounts to 20,000 heat units, corresponding to the heating value of nearly 1½ lb. of coal. According to statistics the average consumption of 73 central stations in the United States and Canada in the period 1914-19 was 4 lb. of coal per kilowatt-hour, the lowest consumption being 1.76 lb. in plants of more than 100,000 kw. The stated average consumption of coal is, therefore, ten times too high to make the common way of heating by electricity in any way profitable.

What has been said of electrical energy holds equally good for mechanical work, these two forms of energy being mutually convertible without any serious loss. It is evident, therefore, that in places where coal or equivalent energy must be paid for, no economic advantage could be obtained from a method of heating where the whole working heat had to be generated by mechanical work or electrical energy.

Steam Ordinarily Used

With the exception of electro-metallurgical work, almost all manufacturing processes requiring heat use steam for this purpose and have done away with the early and rudimentary method of applying directly the heat obtained from the combustion of coal or other fuels. Most of the heating work in the different industries consists in boiling and concentrating liquids, and the common practice is to employ either live steam or, if suitable and available, exhaust steam in the heaters. With small differences of temperatures between the heating steam and the boiling liquid and little loss of heat by radiation and conduction, many types of apparatus will evaporate about one pound of water for every pound of steam condensed in the steam space.

The advent of the multiple-effect apparatus, first introduced in the American sugar refineries, and its later improvements were important steps in advance. They were made many years ago, but apart from the sugar industry multiple-effect apparatus did not come into anything like general use. Their greater bulk, complication and higher cost, as compared with simple apparatus, offset to a certain degree their higher efficiency. The distinguishing feature of the multiple-effect apparatus, consisting of three, four or more evaporating vessels, is the employment of the vapor rising from the liquid in the first vessel to cause evaporation in the next vessel and so on for whatever number of vessels constitutes the series.

The economic advantages of multiple-effect apparatus are of no avail if the evaporation has to be done at a definite temperature or if the liquid under treatment is liable to injury by the high temperature necessary in the first vessel to provide for the successive fall of temperature, on which the principle of the multiple-effect apparatus depends. No such limitations exist with the heat pump. It works equally well at any temperature, and in efficiency and economy surpasses notably a multiple-effect apparatus. The main and important idea of the design of the heat pump is to compress the vapor rising from the liquid to a pressure and temperature sufficiently high that it may be used as the heating medium for the evaporator and cause evapora-

tion in the same vessel, where the vapor is taken from. As all the heat of evaporation is contained in the generated steam, it requires only that small surplus of heat which provides for the necessary difference of temperature at the heating surface and which determines the rate of evaporation.

The simple arrangement of a distiller with a heat pump is shown in Fig. 1. *A* is the evaporator with the heating coil *B*, *D* the water-inlet, *E* the condensed steam or distilled-water outlet. The suction-side of the rotary compressor *C* communicates by the vapor-pipe *F* with the steam space of the evaporator, and the compressed steam is discharged in the tube coil *B*. In condensing therein, the steam parts with its latent heat, which serves to evaporate an equal amount of water. When once started, the mechanical work of driving the compressor is the only source of heat. For starting the apparatus, the heating up of the liquid in the evaporator and the generation of the vapor necessary to begin with, may be done by some live steam introduced in the coil and shut off when the compressor is started.

The expenditure of work may be determined as follows: Let Q be the quantity of water treated per hour, t_1 the temperature of the water entering the evaporator, t_2 the temperature of the discharged water of condensation and H the total external losses of heat by conduction and radiation of the evaporator, compressor and pipes, then the expended work W measured in heat units will be:

$$W = Q(t_2 - t_1) + H$$

This equation is easily verified by the reasoning that the two terms on the right embrace all quantities of

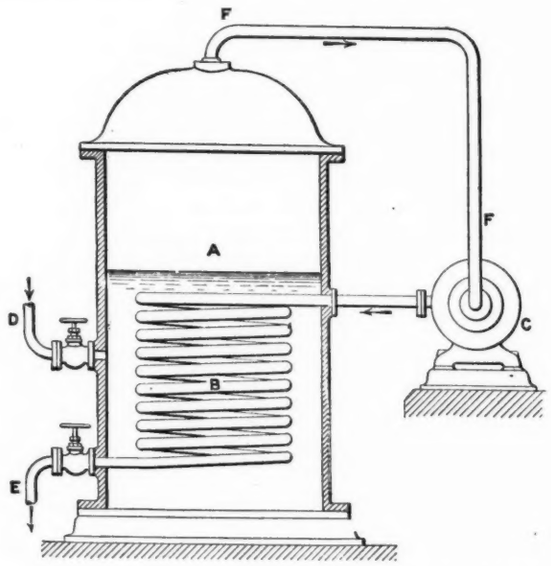


FIG. 1. SCHEMATIC DIAGRAM OF HEAT PUMP AND EVAPORATOR

heat into which the expended work can possibly be converted. The water inlet and outlet valves must, of course, be so regulated that the level of the water in the evaporator remains stationary all the time.

For readers familiar with the theta-phi or temperature-entropy diagram, an evident proof of the foregoing equation is furnished by Fig. 2.

The state-point 1 corresponds to one pound of water entering the evaporator at temperature t_1 or absolute temperature T_1, 2 is the state-point of one pound of dry steam of absolute temperature T generated in the evaporator. By loss of heat in the vapor pipe leading from the evaporator to the compressor, part of the steam condenses and the state-point shifts to 3, the area f representing the loss of heat. Assuming an adiabatic compression from the absolute temperature T to the final temperature T_c, the state-point of one pound of steam is raised to 4. By loss of heat in the discharge pipe the state-point shifts to 5 and the loss of heat is represented by the sum of the areas c and e. The state-point 6 corresponds to one pound of steam condensed in the tube coil or distilled water discharged at the outlet at temperature t_2, or absolute temperature T_2. The total work expended on one pound of steam is represented by the sum of the areas $b + c$, and the several heat losses accounted for are represented by the sum of the areas $c + e + f$. The quantity of heat given off by one pound of steam in the coil must exactly balance the quantity of heat necessary for heating and evaporating one pound of water entering the evaporator. By reference to the diagram, this corresponds to the equality of the areas:

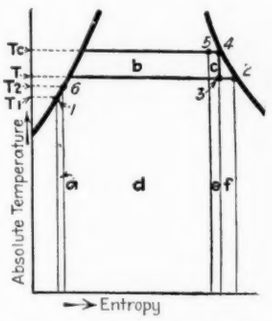


FIG. 2. ENTROPY DIAGRAM OF HEAT PUMP

$$b + d = a + d + e + f$$

By adding c and subtracting d on both sides, one gets

$$b + c = a + c + e + f$$

Now $b + c$ is the work expended on one pound of steam, or W, and $c + e + f$ are the several heat losses per Q lb. of steam, or H. The area a corresponds to the heat necessary for heating one pound of water from temperature t_1 to the temperature t_2, which amounts to $(t_2 - t_1)$ units. Instead of $b + c = a + c + e + f$, one may write

$$\frac{W}{Q} = (t_2 - t_1) + \frac{H}{Q}$$

as stated in the foregoing.

The temperature-entropy diagram of an actual heat pump will differ in some respects from that shown in Fig. 2, mostly because the compression cannot possibly be supposed to be adiabatic, as much work is converted into heat by friction and eddies of the steam in its passage through the guide blades and the revolving wheel of the compressor. For this reason the efficiency of a rotary compressor is seldom higher than 50 per cent.

From the following example the economic advantages of using a heat pump for the purpose of distilling and concentrating liquids may easily be deduced.

An ordinary evaporator of 20 sq.ft. heating surface evaporates at atmospheric pressure about 250 lb. of water per hour, if the gage pressure of the heating system in the jackets or tube-coil or whatever form of heating surface is provided, amounts to 6 lb. This pressure corresponds to a temperature of 230 deg. F., so that the working difference of temperatures at the heating surface amounts to 18 deg. F.

The theoretical work of compressing 250 lb. of steam at atmospheric pressure to 6 lb. gage pressure is 5,593,500 ft.-lb., which, if exerted in an hour, corresponds to 2.8,

say 3 hp. The compressor which works with an efficiency of 50 per cent consumes, therefore, 6 hp. The expenditure of work in heat units per hour amounts to $6 \times 2{,}545 = 15{,}270$ B.t.u. Of this about 1,000 B.t.u. will be lost by friction in the bearings, stuffing boxes, etc., and by radiation and conduction of the compressor. The evaporator and the pipes will, if well protected, not lose more than about 3,000 B.t.u. per hour. The equation becomes, then,

$$15{,}270 = 250(t_2 - t_1) + 4{,}000$$

from which $t_2 - t_1 = 45$ deg. F. If the water or liquid enters the evaporator at a temperature of 80 deg. F., the distilled water will flow out at a temperature of $80 + 45 = 125$ deg. F. To heat one pound of water from 80 deg. F. to the boiling point and to evaporate it, takes 1,099 B.t.u.

If driven by an electric motor, the compressor will consume about 5-kw.-hr. per hr., which may be generated in a steam plant with 70 lb. of steam per hour, so that by means of the heat pump nearly four pounds of water may be evaporated with the expenditure of only one pound of steam. A simple evaporator without a heat pump would consume about 3.6 times as much steam as a distiller with heat pump. If, irrespective of the cost, electrical energy were available, the direct conversion into heat would furnish per kilowatt $\frac{3{,}428}{1{,}099} =$ 3.1 lb. of distilled water per hour, while by using the electrical energy for working the heat pump more than 16 times as much water could be treated.

If the evaporator is worked at a higher rate and the compressor accordingly speeded up, so as to furnish steam of 15 lb. gage pressure, which produces a difference of temperatures at the heating surface of 40 deg. F., about 500 lb. of water per hour might be treated in the same evaporator. The expenditure of work would be about 20 kw., external heat losses would not be materially influenced, but the difference of temperatures of the inflowing and outflowing water would be 114 deg. F. instead of 45 deg. F., as in the former case. If the distilling were done by the direct employment of electrical energy, 160 kw. would be consumed; only 20 kw. are consumed by the heat pump.

By means of the heat pump, therefore, the processes of concentrating and distilling liquids may be carried out in the most economical manner, whether the mechanical work for driving the compressor be furnished by a steam- or by a water-power plant. In the latter case it is worth remarking that industries depending on fuel or heat for concentrating liquids may now totally dispense with steam and fuel. Every possible issue out of the present coal difficulty deserves full consideration and careful study, and in this respect the heat pump, the manufacture of which has been taken up lately by some firms in Switzerland and in Germany, arouses much interest in central Europe.

As the principle of the heat pump is not covered by any patents, everybody is free to apply it. In fact, the principle is not new and attempts to introduce it into practice may be traced a good many years back. They were not successful, as the then-used piston compressors were not adequate for the purpose of handling large volumes of steam and the old-style jet compressors worked with very low efficiencies. The modern high-speed rotary compressor, with the recent perfections brought to it, seems to fulfill all the requirements.

Explosion in Refrigerating Plant

By J. Henderson

After overhauling a plant in preparation for the new season, it was found to be perfectly airtight and it withstood an air pressure of 300 lb. per sq.in. without loss. The system was not fully charged with ammonia, and it was necessary to make a connection to an ammonia container which had just been received. This container was smaller than usual, the supply house stating that it was all they had on hand.

The engineer started the engine and, after regulating everything to its proper stride, tested the system at the purge cock, prepared the compressor for charging and opened the charge valve. He regulated the suction to about 30 lb. gage pressure and pumped over until the pressure showed 5 lb. gage. This was repeated until the discharge gage read 105 lb. per sq.in. The machine then showed signs of slowing down and the engineer attended to it. On his return to the gage board he noticed that the condenser pressure was reading 176 lb. per sq.in. with 15 lb. per sq.in. on the suction gage.

Asking the manager to open the flash (expansion) valve to the storage room as soon as the suction reached 10 lb. absolute, the engineer turned to feel the compressor gland. As he leaned over the engine, a violent explosion occurred overhead. The lights went out and as he began to feel around to stop the engine a second explosion took place, accompanied by a brilliant blue flash which singed everything it touched.

When things cleared up it was found that the compressor water jacket had blown to pieces and the cylinder head was missing. The latter had been raised through the roof, a distance of thirty feet, and on the return trip broke the acetylene lighting fixture over the engine. The main delivery pipe was broken and the crankshaft bent, although the connecting rod and piston rod were not injured. The intercepter at the condenser was also broken. In fact, the entire building and contents were badly strained and injured.

The question arises as to the cause of this explosion. The container was marked "Anhydrous Ammonia" and the freight bill of lading, together with the invoice, bore the same name. There was nothing about the container to suggest anything else except that it was somewhat smaller than the usual ammonia container.

The engineer claimed that the container held oxygen and not ammonia. It is well known that ammonia is slightly combustible when mixed with a sufficient amount of air and exposed to a flame. When mixed with twice its own volume of air, it is violently explosive in the presence of a flame. It is safe to assume that the result would be intensified if oxygen was present instead of air.

Taking into consideration these facts, the engineer claimed that the heat of compression caused the residue left by the lubricating oil in the compressor to become incandescent, thereby causing the mixture of ammonia and oxygen to explode. The flame thus generated continued through the system and on reaching the intercepter ignited the charge there, wrecking the piping, etc. An oxidized scale covered the stem of the retaining valve in the cylinder head; this sufficiently proves the presence of a flame in the compressor.

The average weekly earnings of employees in representative New York State plants supplying water, light and power were $15.66 in 1914 and $36.16 in 1920, according to the New York State Industrial Commission.

A B C of Ammeter Shunts

Actual Ratings and Practical Requirements—Importance of Avoiding Variations in Resistance of Shunt Metals with Temperature, and Thermo-Electric Contact Voltage—General Rules for Installation—Connections to Be Avoided

BY VICTOR H. TODD

IN THE measurement of direct current the average ammeter of the D'Arsonval or permanent-magnet moving-coil type requires about 0.02 ampere in the coil to deflect the pointer from zero to full scale. This average may vary from 0.0005 ampere in a portable instrument to 0.1 ampere in a switchboard graphic, and in fact each instrument may take a slightly different value. Few commercial circuits use so small a current, therefore it becomes necessary to "shunt," "parallel" or "bridge" the ammeter circuit with a low resistor which carries the main current. This low resistor is called a "shunt," and shunts may be obtained with main current capacities from about one ampere up to about 75,000 amperes. Fig. 1 shows the arrangement of ammeter circuit and shunt. Let it be assumed that the resistance of the instrument, including the leads, bobbin, springs and compensating resistance, is 2.5 ohms as measured across points *A* and *B*, while the resistance of the shunt across points *C* and *D* is 0.00501 ohm. Now connect the instrument to the shunt, pass 10 amperes through the line and calculate how the current divides in the split circuit composed of instrument and shunt. Ohm's law says that the current in a split circuit divides in inverse proportion to the resistance of each circuit. Therefore if the current in the instrument is represented by X and the current in the shunt (10 Amperes $- X$) we will get the following proportion: $X : (10 - X) = 0.00501 : 2.5$ from which

$$X = \frac{10 \times 0.00501}{2.5 + 0.00501} = 0.02 \text{ ampere,}$$

and $10 - X = 9.98$ amperes. Although some firms rate their shunts in ohms, the general practice is to rate the shunt according to the voltage drop at a certain current. In the previous example the voltage drop in the shunt, according to Ohm's law, is $E = IR$, or 9.98 amperes $\times$ 0.00501 ohm $=$ 0.05 volt, or in practical terms, 50 millivolts. Above 10 amperes the current diverted by the instrument, which is infinitesimal compared to the total, may be disregarded.

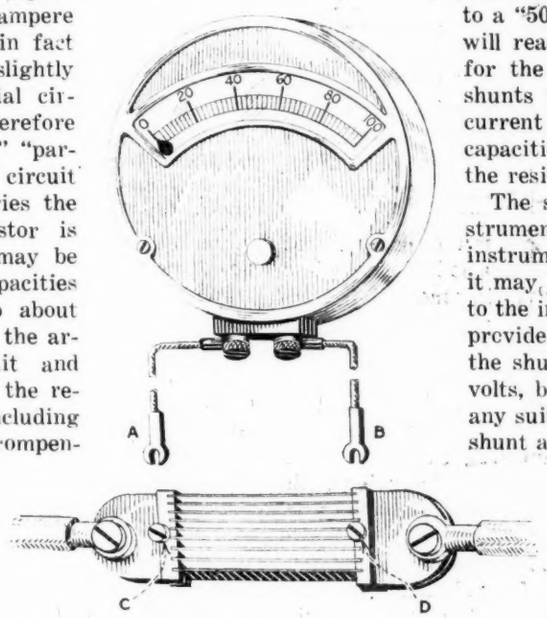


FIG. 1. CONNECTIONS FOR AMMETER AND SHUNT

If the instrument is calibrated to give full-scale deflection on 50 millivolts and is then connected to the shunt, it will be known that the instrument will read full scale when 200 amperes pass through the shunt. This same instrument when connected to a "50-millivolt 10,000-ampere" shunt will read full scale on 10,000 amperes, for the voltage drop in two different shunts may be the same, though the current capacities differ widely, if these capacities are inversely proportional to the resistance.

The shunt may be placed in the instrument itself, forming a self-contained instrument, up to about 75 amperes, or it may be an external shunt, connected to the instrument with the special leads provided for that purpose. The drop of the shunt may not be exactly 50 millivolts, but may be 75 or 100 or 500 or any suitable value. If the ammeter and shunt are calibrated together as a unit, the drop need not be known; but previous practice has so often demonstrated the necessity for various changes in capacity that most manufacturers are making all shunts for a uniform drop at their rated capacity. For ordinary switchboard service this drop is 50 millivolts. Drops of 25 or 30 millivolts are used with potentiometers on standardizing sets, and 75 to 500 millivolts on portable standards.

Modern practice requires accuracy in the measurement of electric currents combined with a minimum of space and loss in the measuring apparatus. The shunts could be made of copper, but this is impractical for two reasons: First, it would take a shunt about six feet long to obtain 50 millivolts on a basis of 1,000 amperes per square inch cross-section, and second, the resistance would change with the temperature and the drop would not be proportional to the current, giving inaccurate readings on the instrument. Cast iron offers a higher resistance per unit length, but its resistance also changes greatly with a variation in temperature.

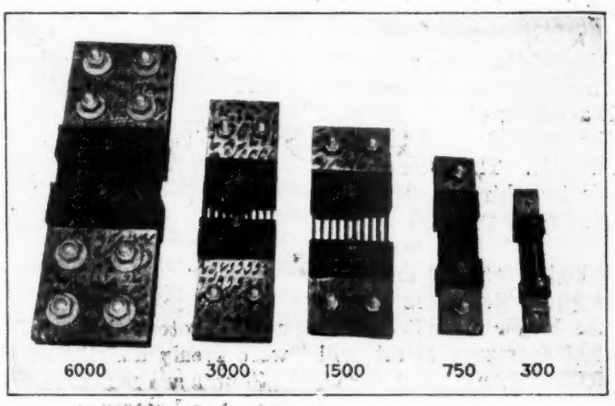


FIG. 2. TYPICAL THIRTY-MILLIVOLT SHUNTS

Many alloys have been tried, but present-day practice has almost universally adopted an alloy of manganese,

nickel and copper called by various trade names such as "Manganim," "Therlo," etc., for the resistance plates of the shunts. Many of the alloys tried gave a high specific resistance, but either varied with the temperature or gave a "thermoelectric" error; that is, the junction of the resistance metal and the shunt terminals produced a small voltage by thermoelectric effect through a non-uniform temperature rise in the shunt. When both terminals were at the same temperature, this effect was neutralized, but was considerable if one terminal became heated to a higher temperature than the other. The alloy of manganese, nickel and copper not only has a high specific resistance, thus enabling a large amount of resistance to be secured with a minimum space, but it also has a very low thermoelectric voltage effect against copper. As illustrated in Figs. 2 and 3, this resistance metal is cut into sheets or strips which are soldered into slots milled in heavy copper castings. These castings are provided with suitable terminals for connecting the leads from the instrument and also for connecting in series with the line. On the smaller sizes line connections may be made by soldering the wires into suitable lugs which are screwed to the shunt; but on the larger sizes (about 300 amperes in one design) the ends of the shunts are milled with slots to receive the leaves of the main circuit busbar (Fig. 3).

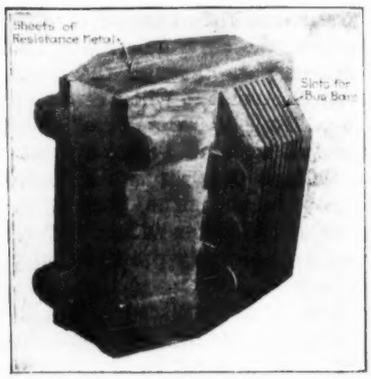


FIG. 3. TWENTY-TWO-THOUSAND-AMPERE SWITCHBOARD SHUNT

Capacity Limited by Temperature Rise

As in most electrical apparatus the capacity of a shunt is limited by the temperature rise. Some manufacturers rate the capacity of shunts according to their temperature rise at two-thirds of the rated full load. For instance, a shunt should be guaranteed not to rise more than 30 deg. C. when carying two-thirds of its rated load.

This also suggests the selection of the proper capacity shunt for a given installation. The instrument and shunt are often selected with a rating of 150 per cent of the full-load current of the generator, in order to allow the measurement of overloads. Then the normal full-load current will produce a two-thirds scale deflection, giving an indication on the most readable part of the scale.

It may appear that if a shunt gives only 50 millivolts drop the loss in energy is inappreciable. This is true in the smaller sizes, but in the larger ones it is considerable. For instance, a 30,000-ampere shunt will consume 30,000 amperes $\times$ 0.05 volt, or 1,500 watts, energy simply lost in the shunt; this is exclusive of other losses in joints and busbars. Yet the actual energy used in the instrument is only 0.05 volt, $\times$ 0.02 ampere, or 0.001 watt.

When installing a shunt, great care should be taken that the line conductors are sufficiently large to carry the rated current without overheating. The surfaces between busbars or lugs and shunt terminals should be brightened with emery cloth and tightly bolted together, or excessive loss and heating may result. Shunts should preferably be mounted in a horizontal position as vertical mounting causes the upper terminal to heat up more rapidly than the lower; this mounting may be used, however, if the shunt is provided with extra-heavy conductors to prevent unequal heating of the terminals.

Whenever possible, shunts with multiple resistance leaves or strips should be mounted with the strips on edge—not flat—to allow free circulation of cooling air among them.

Never connect shunts as shown in Fig. 4. Not only do these connections result in unequal heating and consequent thermoelectric errors, but the actual drop may be in error due to the current seeking the shortest path and consequently crowding to one side of the shunt.

Arrangement Fig. 4 *A* is doubly incorrect. The plates are horizontal instead of on edge, so that cooling air cannot circulate between them, and the heavy bus connection on one end will dissipate heat more rapidly than the light one on the other end, causing thermoelectric errors. Arrangement Fig. 4 *B* will have the same result, since the upper terminal will be kept at a higher temperature than the lower by the heated air from the shunt. Arrangement *C* would be good if the left-hand rising bus connection were horizontal instead of vertical. As it is, there is a tendency for the current to take the shortest path and crowd on the inside of the bend. The current density will, therefore, be higher at this point,

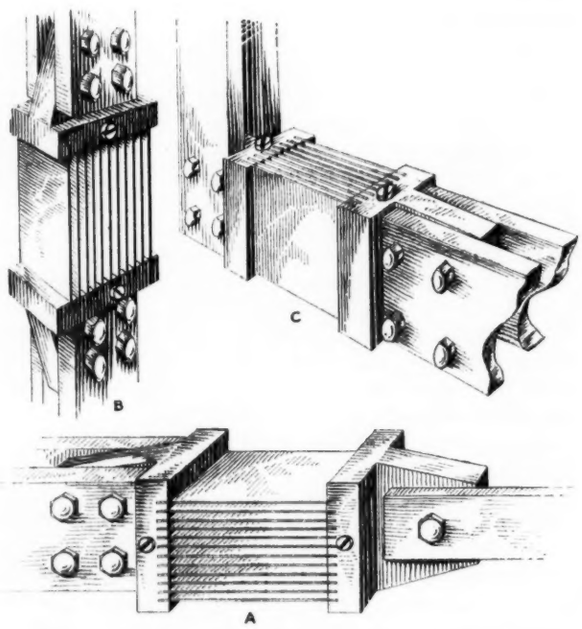


FIG. 4. INCORRECT MOUNTING FOR SHUNTS

and the potential drop will be greater than if the current were evenly distributed in the shunt.

Shunts are seldom if ever used on alternating current, for several reasons: (1) It has been impossible to manufacture a commercial alternating-current instrument operating on 50 millivolts; (2) the inductance of the instrument would cause a phase-displacement error between shunt and instrument, and (3) the current transformer presents an ideal method for the measurement of alternating current.

Efficient Burning of Fuel Oil—VII

By ALLEN F. BREWER

THE extent to which this chapter is going to interest the oil-fuel fireman will depend to a great extent upon the size of his boiler plant and the responsibility placed upon him. It is safe to assume that in average plants the fireman will be given such responsibility as he proves himself capable of bearing. To meet all demands, the following notes are intended to cover as completely as possible all measurements and tests that are customary in the receiving or handling of fuel oil prior to its firing. In order, they are:

Gaging (measuring contents) of a vertical tank	Daily
Gaging (measuring contents) of a horizontal tank	Daily
Measuring water contents in storage tanks	Daily
Measuring temperature of oil in storage tanks	When necessary
Sampling of oil in storage tanks	On receipt of new stock
Measuring gravity of oil in storage tanks	On receipt of new stock
Measuring water and sediment content of oil fuel	On receipt of new stock

It is evident that for most efficient operation the fireman should know, first, the rate at which he is burning fuel, and second, the physical condition of the fuel in the storage tank. The first, if an oil meter is installed, is most easily determined therefrom, though the storage tank should be gaged daily at the same hour whether a meter is in use or not. Without a meter he must depend entirely on gaging. The second factor—physical condition—is of value as a guide to the degree necessary to preheat the fuel, the ease with which it may be pumped and the amount of water and sediment it may contain. This last, if excessive, would of course, tend to cause bad firing or clogging in the burner.

Receiving and handling fuel oil and the usual tests and measurements should be of interest to those who operate large oil-burning plants. This article deals mostly with the gaging, by various methods, of both vertical and horizontal oil tanks. The next article to follow deals with the storage of fuel oil and the precautions to be observed.

Gaging of Vertical Tanks

In order to know the amount of oil in a storage tank at any time, the depth of this oil must be gaged or measured, the figure obtained being afterward converted to barrels or gallons as desired. Gaging can be carried out, either by measuring the depth of the oil directly or by measuring the distance from the gaging point at the top of the tank to the surface of the oil.

Before any tank can be gaged, a certain point must be fixed on the gaging hatch or manhole combing from which all future measurements must be taken. The object of this is evident, since, were we to gage from any part of the hatch or manhole at random, there would be frequently quite a difference due to the possibility of the gaging tape plumb-bob striking a rivet head or seam in the bottom of the tank. Of course the extent of difference would depend on the diameter of the tank; the larger the tank the greater the difference.

On a day-to-day gaging, purely to determine the amount of oil fired, any difference would be of small account, except as it would rai or lower evaporation figures somewhat. In the purchase of the oil, however, quite an item in dollars would result, in favor of or against the purchaser. The gaging point, therefore, should be clearly marked so that it cannot be mistaken. (See Fig. 1.)

The next step, before a tank can be gaged, is to determine its total lepth from the gaging point to the bottom. This measurement should be a constant for the tank, and it is well to paint it on the gaging hatch close to the gaging point. The depth of a tank can be most accurately measured when it is new, because the bottom is clean and an exact measurement can be obtained. On an old tank in which heavy oil fuel has been stored, the bottom will almost surely be covered with a thick sludge, which will make measuring difficult.

Measuring should be done with a steel tape weighted with a plumb-bob. Lower the plumb-bob to the bottom of the tank and measure the height to the gaging point. Do not let the tape sag. To prevent this, "feel" for the bottom with the plumb-bob just barely touching. Check the reading thus obtained several times.

Gaging by method No. 1 is a direct measurement of the depth of oil in the tank. The steps are: First, lower the tape into the tank until the depth of the tank measurement, as previously determined, appears on the tape. Hold this reading exactly at gaging point. No sag should appear in the tape. Then withdraw the tape rapidly to prevent oil from running down and read the oil mark on the tape at least to one-eighth of an inch. If the oil is light, chalk the tape three or four feet above and below the probable depth, to enable an accurate reading to be made, even though the oil may run down the tape. A clearly defined mark is shown where the oil has come in contact with the chalk.

Gaging by method No. 2 is measuring the distance from the gaging point to the surface of the oil, the depth of oil being determined by subtracting this measurement from the constant depth of the tank. The steps are: Lower the tape until several inches of it are immersed in the oil; hold the tape at the gaging point, read it, note the reading and then withdraw; read the oil mark at the bottom of the tape. The difference between the readings is the net distance from the gaging point to the oil surface.

Having obtained the measurements by method No. 1 or No. 2, the next step is to convert the reading to gallons or barrels by means of a gage table. The calculation of such a table will not be treated here. It is out of the fireman's line and should be done in the office. In general a gage table for a steel tank can be obtained from the tank builder if desired. A gage table may be so calculated as to read upward from the bottom of the tank or downward from the top. In the first case gaging should be done by method No. 1. In the second case by method No. 2.

Gaging of Horizontal Tanks

The oil contents in a horizontal tank are measured in a similar manner to that discussed for a vertical tank. Method No. 1, or measuring the depth of oil in the tank,

is generally used, the reading being converted to gallons or barrels by a suitable gage table calculated for the tank in question.

If the tank be new, or for any other reason the fireman has to find his own gaging point, he must bear one idea in mind. No matter what opening he intends to gage from, the point selected must be directly on the top center line of the tank; otherwise considerable error will occur at each gaging.

To locate such a point, a simple method is to stretch a line lengthwise along the top of the tank, moving it as desired till it looks to be directly over the top of the tank. Note and mark plainly the point where this line crosses the hatch or opening where it is intended to gage from. This is the permanent gaging point. There is no accurate method for locating the gaging point over the top center line of a horizontal underground tank after it has been buried. If possible, the gaging point should be located when the tank is set.

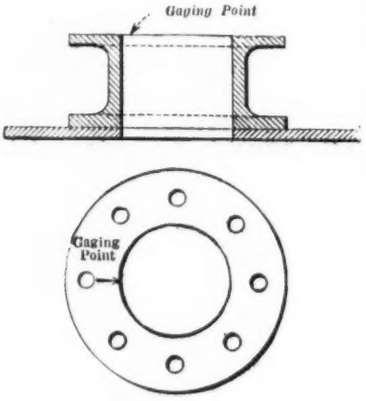


FIG. 1. SHOWING GAGING POINT

The necessity for knowing the depth of water at the bottom of an oil-fuel storage tank arises frequently, when the exact oil contents are desired, or the suction pipe is built so low as to endanger water being drawn into the fuel lines if the water is too deep. A certain amount of water is desirable, especially in a vertical steel tank, to prevent oil leakage through the bottom seams. The depth of water should never be higher than the drain valve, however, and this valve must be opened daily and the water drawn off until oil appears. To measure the depth of the water in an accurate, simple manner, the chalked rod may be used in most cases, unless a very heavy oil is encountered.

How To Measure Depth of Water

Take a round iron rod about one-quarter inch in diameter and of a length about six inches greater than the distance of the top of the drain pipe above the tank bottom. Close to one end drill a hole and fasten a stout line securely through it for lowering. Before a measurement is to be made, chalk the rod thoroughly all over, then lower it into the oil contents through the tank gaging hatch or manhole until it just touches the bottom. Be careful to keep it vertical and let no slack occur in the line, for this would allow the rod to slant and result in a water depth greater than is actually being recorded.

Allow the rod to remain in a vertical position, just touching the tank bottom, for about three to five minutes, to insure a clear line of demarcation. Water will wash chalk away, but oil will not affect it; therefore, after withdrawing the rod and allowing the excess oil to run and drip off it, this line of demarkation can usually be clearly seen and its height measured from the bottom of the rod. This measurement will be the depth of water in the tank. If the chalk is washed off the rod, or to within less than six inches of the top, it will indicate that the water depth is above the drain pipe, and hence it should be drawn off.

In case the oil proves so heavy as to make it difficult to see the extent to which the chalk has been washed off the rod, a simple alternative method can be used in the form of a piece of one-inch pipe, preferably of the same length as the rod.

Drill a hole through one end in which to fasten the lowering line. Then cut a tapered plug that will effectually close the lower end of the pipe. Run a wire of the same length as the lowering line through the pipe and fasten it to the plug with a screw-eye. To take a sample of water contents, lower the pipe, with the plug hanging outside, into the tank, being careful to lower both line and wire uniformly to avoid the possibility of the plug being drawn into the pipe. During the descent the oil passes up through the latter, and when it touches the bottom it will contain a column of water and perhaps some oil above the water, according to the depth of water in the tank. Then draw up sharply on the wire to set the plug in the bottom of the pipe. Raise and lower the latter a few times, letting it drop sharply to the tank bottom. This will drive the plug in firmly, and keep water from leaking out. The pipe now contains a column of water equal in height (very nearly) to the depth of water in the tank.

Withdraw the pipe and carefully pour off any oil that it may contain, until water just begins to flow. Then set the pipe vertical and measure the water depth therein by sticking the chalked rod into it.

It is evident that this method is not so accurate as the chalked rod, owing to the impossibility to get right down to the tank bottom; but it will serve the purpose for any ordinary requirements.

Knowledge of the temperature of oil in a storage tank is an important item to the fireman. Such tanks are usually heated by steam coils, and were the temperature not watched periodically there would be ample possibility for over- or under-heating to occur, which would seriously affect the pumping and burning of the oil, especially if a preheater is not installed. The simplest method to follow, to obtain an accurate temperature rapidly, is to keep a thermometer preferably incased in a metal protector with oil cup in the bottom, constantly suspended in the oil about six feet from the bottom of the tank. It is a simple matter to withdraw the thermometer, note the temperature and lower it again into place.

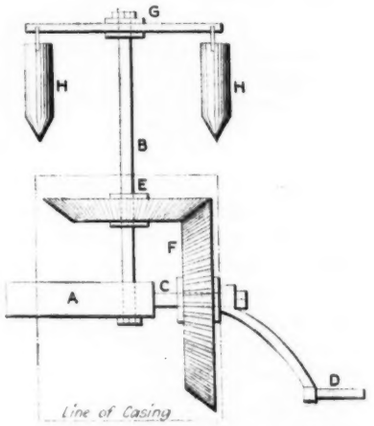


FIG. 2. SIMPLE TYPE OF CENTRIFUGE

Sampling oil from storage tanks may be carried out by either one of the following simple methods. In every case it must be remembered that the sample should be a fair representative of the entire contents of the tank. Sampling is the first step before gravity, or water and sediment content can be measured, as will be explained later.

One method of doing this is with the section of one-inch pipe with plug attached, used for measuring the water contents in the tank, the procedure being similar. It is always best to take the sample from several depths in the oil in order to be sure to get a fair average. The heavier the oil the more will it tend to have varying gravity and water or sediment content at different levels. As each pipeful of sample is taken, pour it into a clean, dry receptacle and mix well.

With method No. 2, instead of using a sampling pipe, a large-necked bottle such as a milk bottle can be used. Fix a weight to the bottom of it to facilitate lowering into the oil. Securely tie the lowering line to the neck, and another line of equal length to a suitable wooden plug, by means of a screw-eye. Cork loosely with the plug and then lower the bottle to the desired depth, being careful to pay out both lines equally. At this depth withdraw the plug from the bottle. The latter will promptly fill with oil, the rate depending on the gravity of the oil. It is well to let the bottle remain in position several minutes to insure complete filling. Then withdraw and treat the contents as described in the foregoing.

When oil is being received from tank car or tank ship through a hose line, it will frequently be possible to sample from the stream flowing into the tank, using an ordinary dipper of about one quart capacity. Take such sample at periodic intervals and pour all into a large, clean, dry container. Mix the contents well before the final test sample is taken therefrom.

All unused oil, as sampled, should be poured back into the tank—never wasted. The amount of waste that will result in a year by continuous throwing out of small quantities of oil fuel is surprising.

Checking the Gravity on Receipt of a Shipment of New Oil

When shipments of oil are being received, it is a decided advantage to the fireman to be able to check up the gravity of the new oil, and the gravity of the resulting mixture in his fuel tank after delivery is complete (if the tank contained an oil of different gravity prior to delivery). He is thus guided as to the degree he must preheat the fuel both in his storage tank and in the oil heater, in order that it may flow evenly and uniformly.

Prior to determining the gravity a suitable sample of oil must be taken, as explained. After thoroughly mixing, fill a suitable jar of sufficient length to prevent the hydrometer from touching the bottom. Gravity is measured by a hydrometer, which is a glass instrument somewhat similar to a thermometer in appearance. Its principle is such that when put into the oil sample it will come to rest at a certain level, depending on the gravity of the oil. The stem is graduated generally in degrees of Baumé gravity; therefore, after the hydrometer has come to rest, the gravity of the oil can be read directly on the glass stem at the level of the oil surface.

The oil temperature should be taken at the same time, since the gravity will vary somewhat according to the temperature; 60 deg. F. is generally taken as a standard. If desired to check the gravity of an oil being delivered, the following corrections may be applied, to correct the gravity to 60 deg. F. For each degree of temperature above 60 deg. F. subtract 0.06 from the gravity as observed. For each degree of temperature below 60 deg. F. add 0.06 to the gravity as observed.

As already stated, the water and sediment content, if excessive in an oil fuel, may cause faulty firing and excessive wear to the burner tip; therefore it is frequently necessary for the fireman to measure them in an approximate manner.

The most suitable device to use in making such a measurement is known as the centrifuge. This machine operates on the principle of precipitating water and sediment from an oil by the use of centrifugal force. Fig. 2 shows the essential features of a simple type of centrifuge that can easily be made on the plant. *A* is a rectangular steel bar serving as the main support for the machine. One end may be left squared for clamping to a table. The other end is turned down to a shaft *C*. Close to the shoulder it is drilled for a vertical shaft *B*. On the shafts *C* and *B* two bevel gears *F* and *E* are set, the latter being the smaller. A handle *D* is tap-bolted to the gear *F*. At the top of shaft *B* a horizontal strip of iron *G* is keyed and bolted firmly in place. At each end of *G* is hung a metal jar *H*, preferably of such diameter that a standard centrifuge test tube will fit in snugly.

To operate, rotate the handle *D*, which will transmit the rotation to *G* in a horizontal plane. This action will swing the jars *H* out into the horizontal when the machine is speeded up.

To make a test, take duplicate samples of oil from the main sample. Dilute each with an equal part of gasoline and fill both centrifuge test tubes to the hundred mark, or top graduation. Then place the tubes in the jars *H* on the machine. Revolve at about one to two hundred revolutions per minute, for about ten minutes, to insure complete precipitation in the oil. The centrifuge test tubes are so graduated that the combined water and sediment, as precipitated, can be directly read as a percentage of the total contents of the tube. Therefore, read both tubes and multiply each reading by two (inasmuch as but half of the sample was fuel oil), to get the percentage of water and sediment.

Laying up the Refrigeration Machine for the Idle Season

By F. A. Clemens

Make sure all stop valves are tight. If not, take off the bonnets and repair them.

Remove the head of the compressor.

Remove the piston, making sure the piston and crosshead are properly marked for clearance.

Inspect the cylinder for wear, making a pin gage to show how much the cylinders have worn. This gage should be carefully put away for future use.

Remove the valves and examine for wear. If necessary, regrind and replace, giving them a good coat of ammonia oil.

Coat the cylinders with ammonia oil after the piston and rings have been examined. Replace and connect, ready to operate.

If solid packing, or packing that requires removal of rod, is used it should be carefully taken out when the piston is removed. Packing that does not require removal of rod should be carefully removed before the piston has been taken out and replaced when the piston has been connected to crosshead.

In most cases it will be found necessary to supply new rings or sections, which the engineer should have on hand.

Before replacing packing, see that the oil-supply pipes are free from obstructions, as failure to supply oil will ruin any packing and be the cause of a shutdown at a time when every minute means dollars.

The crosshead, crankpin and main-bearing boxes should be removed and examined. If necessary, scrape and cut out oil grooves; then replace and key up ready to operate.

All finished surfaces should be coated with a non-corrosive substance, or cylinder oil if nothing else is at hand. Then procure a waterproof covering for the entire machine, which is not only a protection against dust, but also in case of fire.

If the compressors are direct-connected to an electric motor, an inspection of the motor should be made to see if the clearance is even. Dirt should be blown out and the motor covered with a waterproof cover.

If the compressors are engine-driven, the same treatment should apply to them as was given to the compressors.

If the machine is belt-driven, do not remove the belt, but give it a good coat of oil on the outside, as recommended by belt manufacturers. It should then be covered with a waterproof cover.

The foregoing rules for laying up ammonia compressors for any length of time, if followed out, will save a possible shutdown in the busy season, which means a considerable loss in production.

The engineer may say, "The compressors were running all right when I shut down. Why go to all that trouble?" Something may have developed that would not be detected by the operator and which may cause him to shut down and dismantle the compressor at any time. Therefore, a thorough examination will be an insurance against a stoppage in the busy season, which means dollars.

Operation of Chain-Grate Stokers

By F. J. Welch

The operator of the chain-grate stoker should first familiarize himself with its mechanism, paying attention to the parts that need lubricating at regular intervals.

As the majority of chain grates are of the worm-and-gear-drive type the thrust bearing at the end of the worm will require systematic oiling. By disengaging the retaining pawls on the ratchet wheel and backing up the worm, a heavy lubricant can be easily applied. Keep the driving shaft lubricated.

When the boiler is ready for firing run three to four feet of coal upon the grate and start the fire at the feed gate with kindling or live coals. In a few minutes the coal on the grate will be ignited; then fill the hopper with coal and start the machine running. Do not run the grate too fast, causing unburned fuel to be carried over the end of the grate into the ashpit.

The next problem is to evaporate at the proper pressure the greatest amount of water with the least amount of coal. To do this have your boiler clean inside and out, and your baffles tight, so that there will be no "short-circuiting" of gases between the furnace and breeching. Examine closely all places where brickwork and boiler are in contact; you may find bad leaks there. Air leaks make the fuel bill climb fast.

Assuming that you have sufficient draft and that it is required to run as efficiently as possible, and provided you have no draft gages or CO_2 machine, regulate the dampers so that the stack will show a slight tendency to smoke.

Frequently fires will develop holes or burn out on one side of the grate or the other, permitting an excess of air to enter the furnace. This is caused by coal coming down from the storage bin in alternate masses of fine slack and nut size. This particular trouble can be overcome in several ways; as, for instance, if the spout to the hopper is of the swinging type, judicious swinging will overcome the trouble to some extent.

Some stokers of the larger sizes have grates built in two sections and driven from both sides. Then when the hopper shows fine coal in one end and coarse in the other speed up the side with the coarse grade, thereby giving the fine slack time to burn, and the higher speed on the one section will keep the grate covered with fuel and prevent holes and bare spots appearing on the side with coarse coal. (Coarse grades of coal will burn more rapidly than fine slack under equal conditions.)

Have a draft gage for each boiler, with a system of piping leading to all passes, including one over the fire and one for each side of the damper.

Sometimes a damper is set wide open with the expectation of getting the greatest amount of draft. Draft gage readings taken from each side of damper will show that the wide-open position does not always give the greatest amount of draft—a partly closed position will often give more. In other words, the actual position of dampers to give the greatest amount of draft over the fire is determined by the direction of flow of gases to the breeching. Determine the depth of fire necessary by the amount of draft available.

Do not run with a very thin fire and a high speed of grate; better a deeper fire with slower speed—there is less danger of pulling or pushing holes in the fire bed. Remember that draft is not a pull, but a "push," for the air in boiler room is heavier than the air and gases in the furnace and pushing its way through the fuel bed; and if furnace, breeching and stack are of the proper design you will have a very good push to make draft.

Some types of boilers have the superheater elements between the first and second banks of tubes. In such cases be sure to keep them clean by frequent and systematic blowing; otherwise the spaces between will become clogged with fine dust carried over by the draft. In such types of boilers it will be of advantage to have a pipe for taking draft readings above and below the superheaters.

Be sure in all cases to have pipes installed for draft as nearly as possible in the center of the path of the gases; avoid getting draft pipes in pockets where air currents are simply "swirling," and as a result give false draft readings.

With fine slack coal be sure to have it thoroughly dampened with water or exhaust steam.

A sharp decline in the demand for coal is reported from Sweden. English importers have in that country been pushed to the wall by American competition, but they seem to have made up their minds now to underbid American prices. Recent quotations show a reduction of from 30 to 40 per cent, evidently caused by the business depression in Sweden. The country seems to be saturated with coal. The 4,800-ton cargo of the American coal steamer "Dicto" has been sold at the exchange auction in Stockholm at from $8.50 to $13.50 per ton.

Chimneys—Construction and Protection*

Methods of Guying Stacks—Determining Sizes of Guy Ropes—Steel-Stack Joints—Materials Used in Chimney Construction—Protecting Chimneys Against Lightning

BY TERRELL CROFT

A STEEL chimney may often be built inside the boiler house, midway of the battery of boilers which it serves. This is feasible owing to the small outside diameter of a steel stack. Building the stack in the boiler room is an advantage, inasmuch as it minimizes the length of the smoke conduit. This insures maximum draft and reduces installation expense. Further space saving may be effected by mounting the stack on the breeching, but this should not be done when it can be avoided.

Steel chimneys, or stacks, may be classified according to the method of supporting them: namely, guyed stacks, or those which are held upright by guys only (Fig. 1); semi-self-sustaining stacks, or those which are held upright partly by the foundation and partly by guys, Fig. 2; self-sustaining stacks, or those wholly supported by the foundation, Fig. 3.

A chimney that is not self-sustaining must be braced or guyed with steel ropes. This is necessary: (1) When the stack is steel and supported on the breeching (Fig. 1); (2) when the stack is too tall to be self-supporting by anchoring with anchor bolts at the bottom to its foundation; (3) when it is not feasible to provide a base or foundation sufficiently large to support the stack against overturning.

If the stack is set upon a separate foundation, usually one set of guy ropes will be sufficient, but where a stack

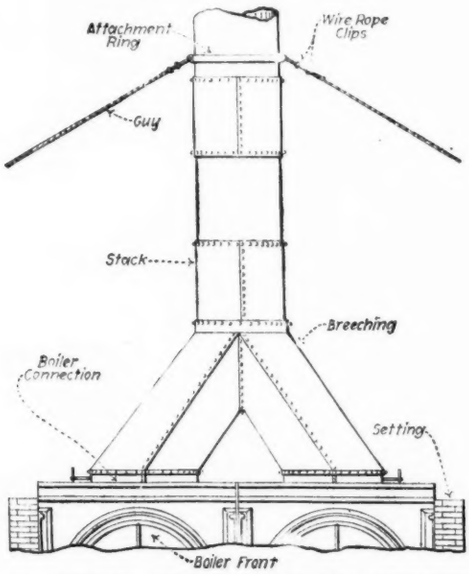


FIG. 1. METHOD OF GUYING STACK MOUNTED ON BOILER BREECHINGS

is supported by the breeching, Fig. 1, a very unstable structure results and it should have more staying, usually two sets of guys having three or four ropes in each set.

Where one set of guys is provided, they should be attached at a location about two-thirds the height of the stack from its base. Where there are two sets, one is attached at about two-fifths the height and the other at about four-fifths the height. Where there are three sets, they are attached at about two-sevenths, four-sevenths, and six-sevenths the height. Guy ropes should be attached to guy bands which are riveted to the stack as shown in Fig. 4. Other means of fastening are used, but the band

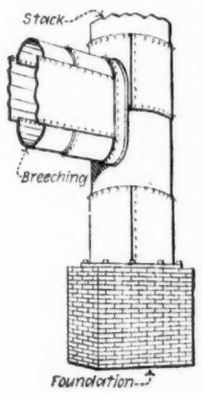


FIG. 2. STACK WITH BRICK FOUNDATION

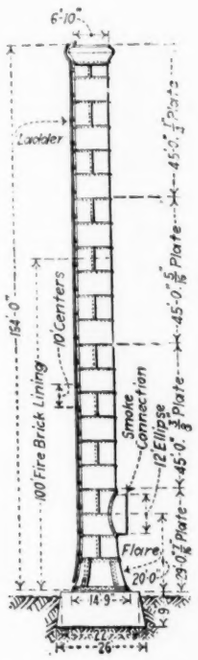


FIG. 3. SELF-SUPPORTING STEEL STACK

is preferable because it affords a strong, economical construction.

To determine the size of guy rope to use for a stack, the following approximate procedure may be adopted: Exact rational methods are impossible. Assume that the force due to the wind is supported by only one guy in each set and by the foundation, if it is suitable. That is, if there is one set, assume that one guy and the foundation take all the horizontal force imposed on the stack. If there are two sets, assume that one guy from each set and the foundation resist the force. Compute the horizontal force imposed on each guy as follows: For the top guy the load will be the force of the wind pressure, Fig. 5, against all the projected area above the point of attachment plus that against 0.6 the projected area between the point of attachment of the top guy and the next lower guy, or the top of the foundation in case there is only one set of guys.

For other than the top guy, where there are more than one set, take 0.6 the projected area between it and supports or guy-wire attachments above and below. This 0.6 instead of 0.5 is assumed to correct partly for irregular initial tension and other indeterminate stresses. Some designers use a value of 0.7 instead of 0.6. Divide the horizontal force, as already computed, by the sine of

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the angle, Fig. 5, between the stack and guy. This gives the tension in the guy. To allow for initial tension, add 2,500 to 5,000 lb. for guys from $\frac{1}{2}$ to $\frac{7}{8}$ in. in diameter.

A steel stack 150 ft. high and 4 ft. outside diameter is guyed at 100 ft. from the ground. If the guys make a 45-deg. angle with the stack, what stress must be taken by it when the wind pressure is 25 lb. per sq.ft.? *Length of projected area is distance above guy attachment + 0.6 distance between guy and foundation, or* 50 + 60 = 110 *ft. Projected area* = 4 × 110 = 440 *sq.ft. Horizontal force* = 25 × 440 = 11,000 lb. *Pull along guy* (Fig. 5) = *horizontal force ÷ sine A* = 11,000 ÷ *sine* 45 *deg.* = 11,000 ÷ 0.707 = 15,550 *lb., or about* 7¾ *tons.* From Table I a ¾-in. rope is required, but since the initial tension must be considered as being about 4,500 lb., or 2¼ tons, this should be added, making the total tension equal 2¼ + 7¾ = 10¼ tons. Table I shows that a ⅞-in. rope is required.

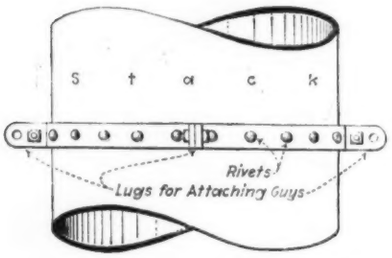


FIG. 4. GUY BAND RIVETED TO STEEL STACK

The lap of the riveted girth joints of a steel stack may be upward or downward. When the outside lap is downward, Fig. 6, there may be a leakage of the soot through the joint to the outside. Acids are carried by the soot, and the paint may be destroyed and the stack thereby corroded. A joint of this type prevents the rain and snow from lodging and running to the inside of the stack, and it offers minimum resistance to the flow of the flue gases. However, when the courses lap upward on the outside, Fig. 7, the joint may be made watertight by using metallic cement. The joint may be calked if it is required that it be exceptionally tight. To prevent the trickling liquid, which may contain acid and which runs down the inside of the stack, from being drawn into the joint by capillary attraction, a lip, Fig. 11, is sometimes turned on the uppermost courses.

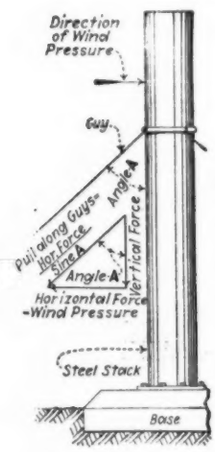


FIG. 5. COMPUTING TENSION IN GUY ROPES

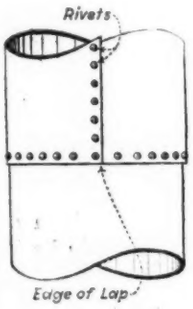


FIG. 6. GIRTH JOINT LAPPED DOWNWARD

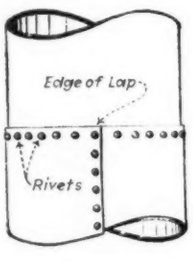


FIG. 7. GIRTH JOINT LAPPED UPWARD

In proportioning the riveted joints in a steel stack the rules of practice require that the pitch, or distance from center to center, of the rivets be approximately 2.5 times the rivet diameter, provided this factor gives a pitch, Fig. 8, less than 16 times the thickness of the plate. If the latter provision is not fulfilled, a factor less than 2.5 must be used. Also, it is required that the rivet diameter be greater than the thickness of the plate, but never less than 0.5 in. Single riveting is usually employed for all joints except the base joint, Fig. 9, where staggered double riveting is used. In stacks of very large diameter all circular seams are double-riveted to insure rigidity.

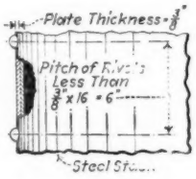


FIG. 8. PITCH OF RIVETS

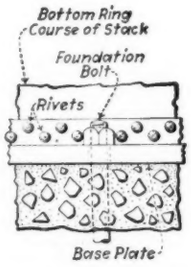


FIG. 9. RIVETED JOINT AT BASE OF STACK

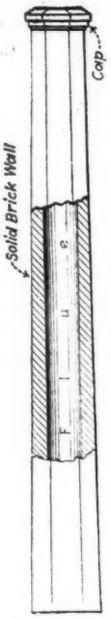


FIG. 10. SINGLE-SHELL BRICK CHIMNEY

Stone chimneys are seldom built, but the principles involved are very little different from those relating to brick-chimney construction.

Brick is widely used for building chimneys. The two types of brick chimneys are: Single-shell, Fig. 10, and double-shell, Fig. 12. The single-shell chimney is serviceable only where brick of an especially good quality and not affected by heat is available. The double-shell—that is, the lined chimney—is the most common type. The lining is independent of the outer wall, thus allowing each wall to expand and contract freely without affecting the other.

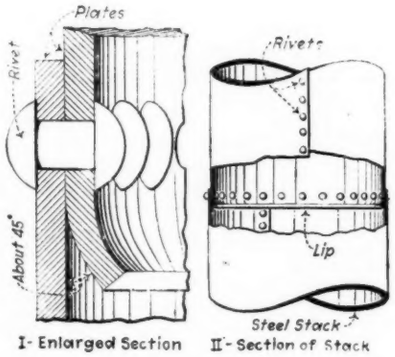


FIG. 11. LIP TURNED ON EDGE OF INSIDE LAP

Buttresses are sometimes sprung from the outer shell to stay the inner shell, Fig. 15. This allows the inner shell to expand without interference. The buttresses should be spaced equally and should stand at least one inch clear of the inner shell. There are usually eight

of them. The annular space between the two shells should be at least two inches at the top. The batters of the shells should be so adjusted as to increase this distance to eight or more inches at the bottom. Facility of construction requires that the thickness of chimney walls diminish abruptly, from bottom to top, in a series of steps, or courses, as indicated in Fig. 12, instead of tapering off gradually. The thickness of the top course of an outer shell built of common brick may be found by the empirical formula:

$$L_t = 4 + 0.05d_i + 0.0005L_h$$

where L_t = thickness of top course, in inches; d_i = inside diameter of chimney at the top, in inches; and L_h = height of chimney, in inches. The practical thickness is taken as that nearest to which the chimney can be built with brick.

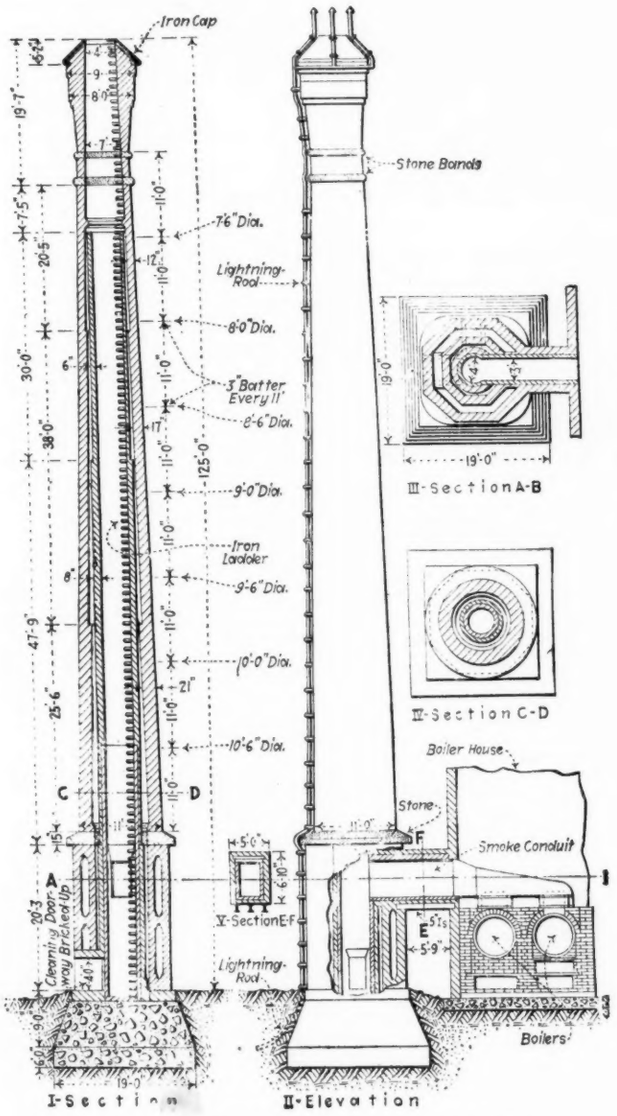


FIG. 12. DOUBLE-SHELL BRICK CHIMNEY

Each succeeding course of twenty-five or thirty feet, starting at the top of the chimney should be increased in thickness about four inches. For example, if a chimney is 100 ft. high and the top is 8 in. thick, it might be built of four courses, each with a height of 25 ft. Each course would increase 4 in. in thickness.

Materials for brick chimneys should be hard-burned close-grained bricks for the outer shaft and second-class firebricks for the core. The outer brickwork from the foundation up to a plane where the winds will have a fair sweep against the chimney should be laid in lime mortar well strengthened with cement. The upper portion is required to have a certain resiliency to offset the stress of high wind pressure, and this is best secured by the use of lime mortar containing a smaller admixture of cement. Since lime does not cling tenaciously to hard, smooth surfaces the harder the brick the higher percentage of cement used. The core is laid with pure lime mortar or fireclay. Cement mortar is not recommended for any part of the core because it disintegrates in the presence of carbon dioxide and especially at high temperatures of the gases.

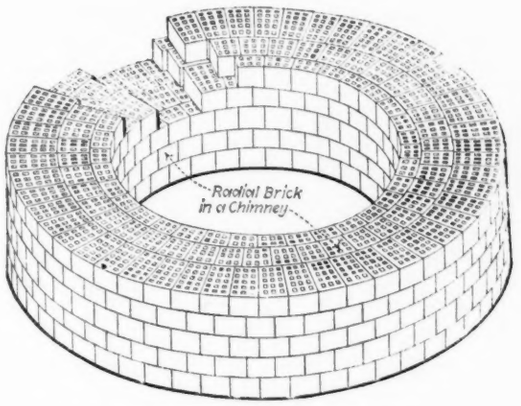


FIG. 13. SECTION OF RADIAL-BRICK CHIMNEY

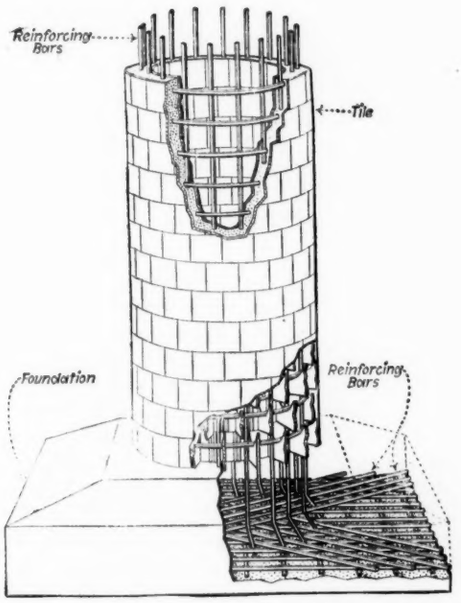


FIG. 14. WIEDERHOLDT TILE CHIMNEY

Radial bricks are preferable to common bricks for building round chimneys as they are better appearing and make a stauncher job. Radial bricks are made with different radii, to suit all degrees of curvature. They can be laid, Fig. 13, more compactly than common brick,

which require thick mortar joints to fill out the irregularities. A circular column built of these radial bricks makes a very strong structure, because the bricks are virtually keyed in. In addition, strength against cracking is added by laying steel bands within the wall.

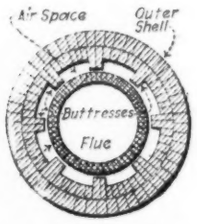


FIG. 15. HORIZONTAL SECTION OF BRICK CHIMNEY

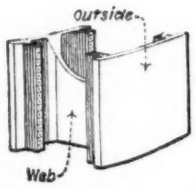


FIG. 16. TILE FOR WIEDERHOLDT CHIMNEY

Radial bricks are perforated vertically with square holes. The weight of the brick is thus reduced. Furthermore, the facility which the holes give for thorough

TABLE I. PROPERTIES OF GALVANIZED IRON GUY ROPE

Diam., In.	Circumference in In.	Approximate Weight per Foot, Lb	Approximate Strength, Tons (2,000 Lb.)	Circumference Manila Rope of Equal Strength
1 1/2	5 1/2	4.85	42	11
1 3/8	5 1/4	4.42	38	10 1/2
1 1/4	5	4.15	35	10
1 1/8	4 1/2	3.55	30	9 1/2
1 1/16	4 1/4	3.24	28	9
1	4	3	26	8 1/2
1	4	2.45	23	8
15/16	3 1/2	2.21	19	7 1/2
7/8	3 1/2	2	18	6 1/2
13/16	3 1/4	1.77	16.1	6
1	3	1.58	14.1	5 1/2
15/16	2 3/4	1.20	11.1	5 1/4
7/8	2 1/2	1.03	9.4	5
13/16	2 1/4	0.89	7.8	4 1/2
3/4	2	0.62	5.7	4
11/16	1 3/4	0.50	4.46	3 1/2
5/8	1 3/4	0.39	3.39	3
9/16	1 1/2	0.30	2.35	2 1/2
1/2	1 1/4	0.22	1.95	2 1/4
7/16	1	0.15	1.42	2
3/8	1	0.125	1.20	1 1/2
5/16	1	0.09	0.99	1 1/2
1/4	1	0.063	0.79	1 1/4
3/16	1	0.04	0.61	1 1/4

burning insures added strength and density. The mortar is worked into the perforations to a depth of about half an inch. The aggregate body of air confined in the

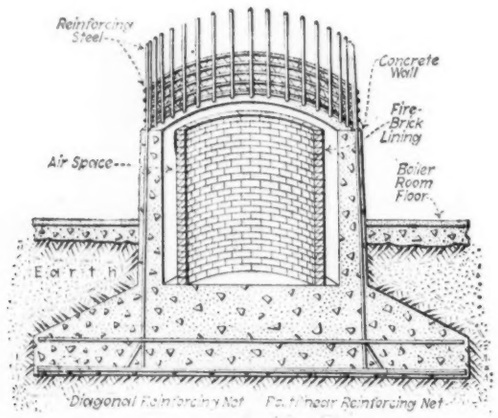


FIG. 17. REINFORCED-CONCRETE CHIMNEY

multitude of pockets formed by the perforations acts to insulate the structure against heat transference. Hence the radiation is materially less from a radial brick structure than it is from one of solid brickwork. A method of reinforced tile-concrete construction for power-plant chimneys is illustrated in Fig. 14. The hard-burned fireclay tiles, Fig. 16, used with this method make permanent forms for the concrete, and the concrete is reinforced with steel bars, as shown in Fig. 14. The successive vertical bar-lengths are made to overlap sufficiently at their ends to develop full strength at the joints. Thus, a practically continuous steel reinforcement from the base to the top of the chimney is assured. The concrete foundation is reinforced with twisted steel bars. These are placed in layers running alternately parallel with the sides and diagonally across the foundation. Reinforced-concrete chimneys are desirable for numerous reasons. They may be built rapidly, and are strong because they are reinforced with steel rods, Fig. 17, which take the tension on the windward side. Their reduction in weight over a brick chimney permits smaller foundations than are required for the latter, and they do not occupy so much space as brick chimneys. The interior is smooth, thus minimizing friction. As concrete chimneys are practically airtight, there is no air leakage which might decrease the effective pressure. Disintegration of concrete stacks by the weather is not so noticeable as in steel stacks. Removing the soot from the base of a chimney, where the plant is in continuous operation, should be done with due regard for comfort and cleanliness in the neighborhood of the plant. Flushing the soot out with a stream of water, Fig. 18, is a good way to accomplish this. A section of 2-in. pipe, attached to a length of firehose, is inserted through the clean-out opening at the base and extended very nearly to the opposite side. The clean-out door is temporarily replaced with a wooden cover, which has an opening at its lower edge large enough for admission of the pipe and for the issuance of the mingled stream of water and soot. As the soot is washed out, the upper surface remains undisturbed.

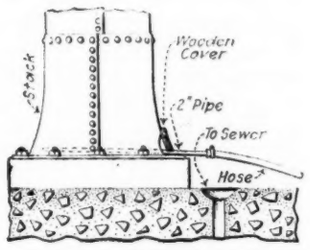


FIG. 18. FLUSHING OUT SOOT FROM BASE OF STACK

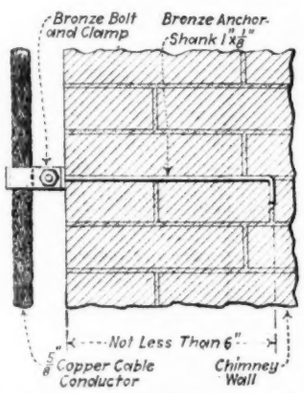


FIG. 19. ANCHOR CLAMP FOR SECURING CABLE

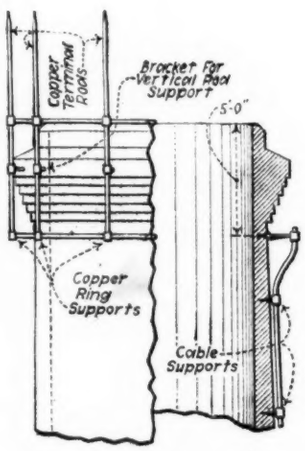


FIG. 20. CHIMNEY TOP, SHOWING TERMINAL RODS

The tops of brick chimneys should be protected from the weather by a cast-iron cap, Fig. 12; at least four ⅞-in. copper studs, for securing the cap, should be left projecting up from the brickwork at the top. The studs are riveted over after the cap is set in place. For protecting masonry chimneys from lightning damage (steel chimneys seem to be immune when grounded) the standard specifications adopted by the United States Navy Yard power plants may be followed. These specifications require from two to four lightning conductors, according to the height of the chimney. Where the chimney is 50 ft. in height there are required two conductors; 50 to 100 ft., three conductors; 100 ft. and higher, four conductors. The conductors are of seven-strand copper cable of approximately ⅜-in. diameter and arranged symmetrically about the chimney. Each conductor is anchored to the chimney wall by bronze or brass clamps, Fig. 19, in which the cable is clamped at intervals of ten feet. Every fifth clamp is further secured by soldering. At their upper ends the conductors are attached to a 1½ x ½-in. copper ring, which encircles the chimney five feet below the top, Fig. 20. The ring is bolted to bronze or brass brackets which are anchored in the chimney wall, Fig. 22, and spaced not over two feet apart. A number of upwardly projecting terminal rods, Fig. 21, ¾-in. in diameter and at least ten feet long are attached to the copper ring at equidistant locations not over four feet apart. These terminal rods are rigidly supported by a copper spider resting on top of the chimney, Fig. 23. Each terminal rod or point is shielded from the corrosive effects of the chimney gases by a thin sheathing of lead which, in accordance with the Navy specifications, extends down about two feet from the point, Fig. 21. At the base of the chimney each conductor cable is inclosed in a 1½-in. galvanized-iron pipe extending three feet into the soil and ten feet above. The cable is electrically connected to the top and bottom ends of the pipe by driving in a metal wedge between the cable and the pipe. The lower end of each cable is securely attached, both mechanically and electrically, to 3 x ½ x 36-in. copper earth bars, Fig. 24. The earth bars are set below the ground-water level, in no case less than fifteen feet below the surface.

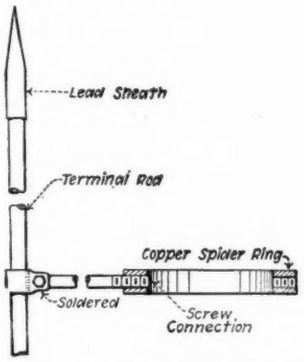


FIG. 21. COPPER SPIDER AND TERMINAL ROD

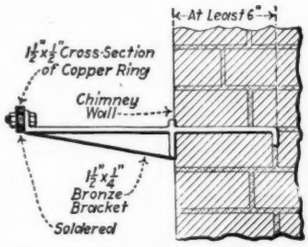


FIG. 22. COPPER TERMINAL RING BRACKET

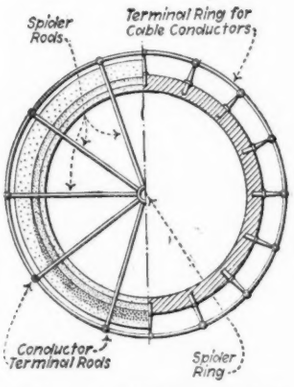


FIG. 23. COPPER SPIDER ON CHIMNEY TOP

All lightning conductors near the top of the chimney should be sheathed with lead. Although some specifications are more liberal, best practice dictates that all copper located above and all below the top within two feet should be sheathed in lead, and this the specifications of some of the most experienced and prominent engineers so direct. While a square masonry chimney is the easiest to build, it is not desirable because the draft which it provides is not so good as that produced by a chimney of equal flue area and round section. This is due to the greater friction offered by sharp internal corners of the square chimney. The area of a square is not as large as the area of an octagon or circle with the same perimeter. Hence, a larger flue is available with the same material if the chimney is round in section. The round chimney gives from 1 to 2 per cent greater draft pressure than a square one of the same flue area. The diameter of the base of a chimney is often taken as one-tenth to one-eighth the height, but this should not be accepted as a definite rule.

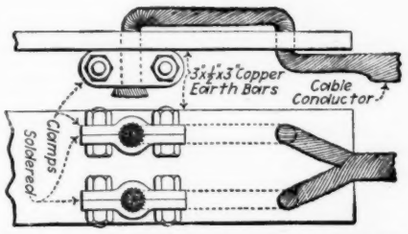


FIG. 24. EARTH BAR FOR LIGHTING CONDUCTORS

Brick stacks are assumed to have a life or expectancy of about thirty-three years (Chicago Traction Co. case, and from Chicago appraisals by Floy) and steel stacks an expectancy of twelve to fourteen years (San Francisco rate hearings in 1913 and 1914, and from Chicago appraisals by Floy).

(This is the second article of three. The next and last installment will discuss the construction and shape of breechings.)

Some Pointers for the Fireman

When coming on duty in the boiler room test the water level by trying the gage cocks; blow out the water column; inspect the condition of the fires and also the ashpits; examine the boiler for steam leaks; inspect the feed pumps; notify the engineer and relieved fireman if anything is wrong and see that proper repairs are made. The water level should be kept at about one-half the height of the gage glass. Fires should be kept clean and level without any airholes. Keep the ashpits clean.

Do not burn coal any larger than your fist. If much coal sifts into the ashpits, throw it back on the coal pile. Fire light and often. Spread the coal evenly. Watch the rear of the grates and between the firedoors. Regulate the draft by the dampers and not by the ashpit doors.

If a sudden increase in load is expected, raise the water level so as to have a large reserve supply. Remember, however, that high water causes wet steam, which results in inefficient operation of the turbines. Also there is danger of priming and water might be carried over into the turbine. If you are expecting a sudden drop in load, lower the water level somewhat. When the drop comes, you will have a chance to pump in water to hold down the pressure until the fires are reduced.

The Care and Operation of Gas-Engine Igniters

By EARL PAGETT

THREE types of ignition devices are found in general use—the hot tube, the jump-spark and the make-and-break igniters. The hot tube is in general employment on gas engines installed in the oil fields. These engines receive rough treatment and operate for long hours without attention. The hot tube, while it is very inefficient and subjects the engine to occasional violent preignition, is practically trouble proof. Although in no wise advisable for general work it is quite suitable for this rough and heavy service. In Fig. 1 is shown a typical hot tube. The hot tube *A* is kept red hot by means of the burner *B*, although the heat of explosion assists in maintaining the high temperature. The piston forces the mixture of gas and air up into the tube, where it explodes when the correct pressure and temperature are reached. Adjusting the length of the tube and the position of the burner will change the timing of the explosion.

The igniter is the very heart of a gas engine. Although every other part is correctly adjusted, the slightest irregularity in the action of the ignition mechanism speedily shows up in the behavior of the engine. The igniter is such a simple device that many engineers fail to give it the proper attention; many even do not understand the principle of its action.

The jump spark is used on many high-speed engines, but only occasionally is this system found on the larger gas engines, and it is therefore not of general interest to many engineers who are operating stationary power plants.

Some form of make-and-break ignition is used on all large engines, and the principle of operation of the system should be understood by all engineers. The mechanical make-and-break ignition consists primarily of two electrodes, one stationary and insulated from the engine, the other one movable and actuated by a tripping mechanism. The igniter body appears in Fig. 2. The movable igniter arm *G* rests under the push rod nut *F*, which in turn is controlled by the cam *A* mounted on the layshaft. As the camshaft *B* revolves, the cam *A* raises the push rod *C*. The igniter spring *E* brings the movable electrode tip against the stationary electrode. The low-voltage current from the battery starts flowing across the igniter tips. At the moment the cam passes its high side under the push rod, the latter falls, causing the movable electrode to break the current, producing a spark at the tips.

In operating igniters of this type it is necessary that the fit between the movable electrode and its bushing be absolutely tight. If there is the slightest leakage carbon will deposit and cause the electrode to stick. A supply of electrodes and bushings should be kept on hand. Each electrode should be fitted to its individual

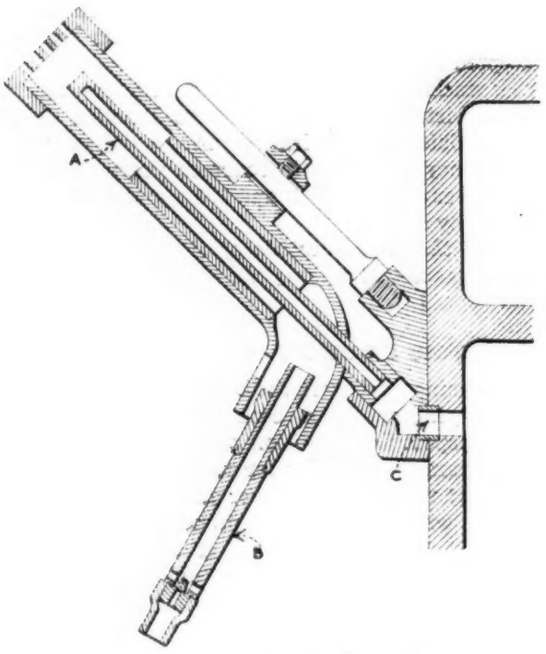


FIG. 1. HOT-TUBE IGNITION

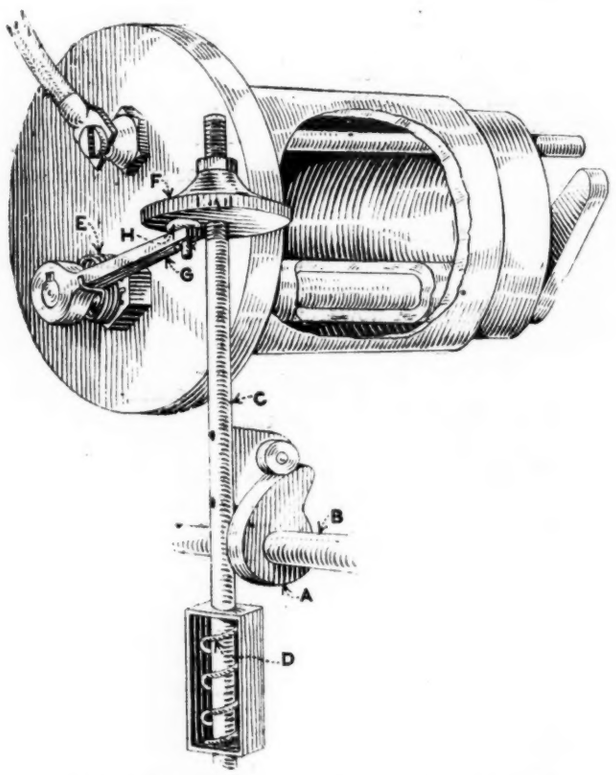


FIG. 2. MECHANICAL MAKE-AND-BREAK IGNITION

bushing and never separated. Grinding paste serves to make the fit gastight. As an additional precaution against sticking of the electrode due to carbonization little if any oil should be used on the electrode.

Provided a reliable source of electric current at the proper voltage is obtainable, no trouble should be experienced as long as no moisture gets into the cylinder. If moisture deposits on the electrode, it will speedily soak through the mica bushing of the

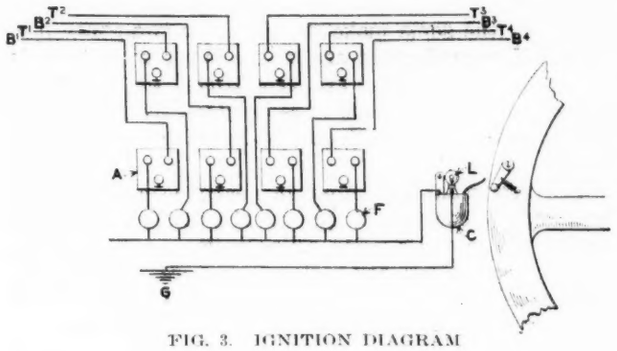


FIG. 3. IGNITION DIAGRAM

stationary electrode and short-circuit the igniter. Placing the igniter over a gas flow will bake out any moisture.

It is never advisable to attempt to replace an igniter while the engine is running. At times this does become necessary, and it can be done successfully if extreme care is exercised. The load must be lowered until the remaining cylinders can handle it. The gas supply to the cylinder in question must be cut off and the exhaust-valve blocked open. The igniter can now be replaced, but under no circumstances should the ignition current be turned on until the igniter body is bolted fast into place. The exhaust valve must be securely blocked open to prevent the cylinder compression from blowing the igniter out before being made secure.

Testing for a Ground

It is very easy to detect a ground in the ignition circuit. If one leg is grounded, disconnect the load from the stationary electrode and with the current turned on, touch the lead lightly upon the engine frame. A good spark results if the wiring and current supply is in working condition. Next, with the electrode points separated, touch the lead to the stationary electrode. If a spark results, this electrode is grounded. The electrode points, when pitted, will give only a faint spark when the lead is touched to the movable electrode with the electrode points held in contact.

The foregoing methods should not be used around a gas compression station since an open spark might ignite a pocket of gas. A lamp inserted in the line will light up and indicate shorts, etc. Each ignition circuit on the majority of large engines has an induction coil or spark coil in series with it, and in some instances there is a "telltale" armature at the end of the coil which serves to indicate the proper action of the ignition system. The coil is merely a bundle of soft iron wires surrounded by a coil of copper wire carrying the current. This serves to increase the temperature and duration of the arc at the igniters. Fig. 3 shows a typical wiring diagram for a four-cylinder engine. The leads marked *T* and *B* lead to the top and bottom igniters, *A* being the spark coil, *F* the fuses and *G* the ground. At *C* is placed a cutout actuated by the weight on the flywheel.

The timing of a gas engine is of extreme importance. The sparking position varies from 10 to 15 deg. before dead center on small and medium-powdered engines to as high as 40 deg. on engines having larger cylinder dimensions. With the latter type early sparking is necessary to obtain ignition of the entire cylinder contents at or close to dead center. To time the engine it should be barred over until the crank is at the proper angle. This is conveniently measured on the flywheel face in inches. The igniter cam is then shifted until the trip drops.

An experienced engineer can always detect any mistiming by the action of the engine, the sound of the exhaust and the color of the gas flame blowing out the indicator cock. The sound when the ignition is early is very clear and sharp while late ignition gives out a dull thump. If a blue flame accompanies the sharp sound, the timing is clearly too early. If the flame is yellow, the mixture is too rich and caused the pound rather than early timing.

Many engines are fitted with the electromagnetic-operated igniter. This is outlined in Fig. 4, where the

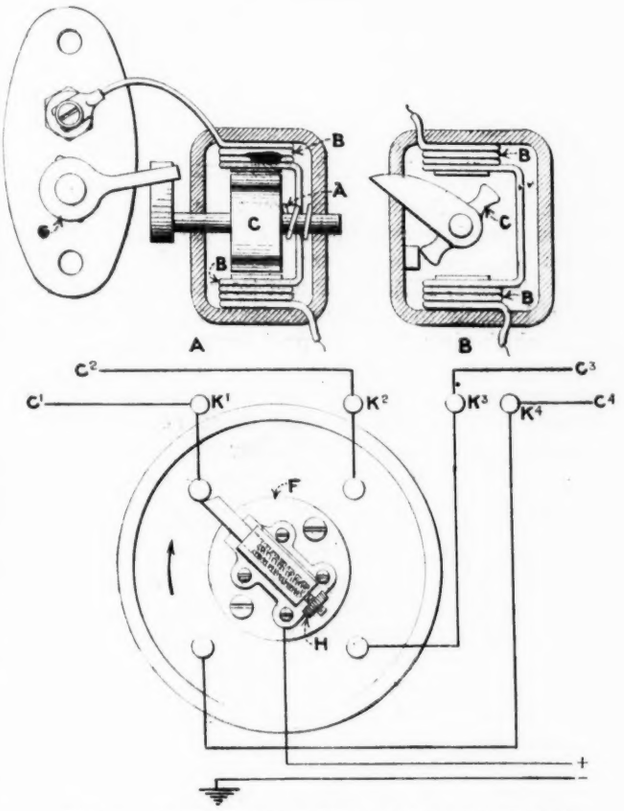


FIG. 4. ELECTROMAGNETIC MAKE-AND-BREAK IGNITION

usual tripping mechanism is replaced by the electromagnet. This consists of two coils wrapped around polepieces and carrying the current to the igniter. Between the polepieces is placed the armature *C*. As the timing dog contacts with the terminal and energizes the line *C*, as shown in the lower drawing, the current passes through the coils *B* and to the igniters which are in contact. The lines of force set up between the two polepieces cause the armature to move to a vertical

position. This movement trips the movable igniter, breaking the circuit and producing a spark at the igniter tip. As soon as the circuit is broken no current flows through the coils, thus allowing the armature to again move into the position shown at *B*. At this time the timer *F* breaks the circuit, thus conserving the current. The timer is mounted, as a rule, on the end of the camshaft and has a shifting lever whereby the timing can be altered while the engine is running.

The timer case must be kept filled with a good grade of transformer oil since the arc is broken in oil. The chief trouble with this type of timer is the burning of the contacts, especially when the oil level is allowed to become low. Dressing with a file will smooth up the contact face. In detecting trouble, if all the igniters save one work satisfactorily either the igniter, the tripping coil or the individual contact is in bad order. If the lead is disconnected from the stationary electrode and held against the engine frame, the tripping coil will function properly if in good order, and the electrode has been at fault. If the tripping action is below normal the coils may be partly short-circuited or the timer contact point corroded. A decided short-circuit will blow the fuse *K;* on the other hand, if the timer contact is short-circuited the main fuse will blow. A voltmeter placed in the supply line will show a decided change at each contact, serving to locate any single fault in the timing.

Seattle Municipal Steam Power Plant

BY H. J. MACINTIRE

The City of Seattle carries on a general public utility business including the operation of the local street cars, street lighting and general power and light supply. Until March 1, 1923, the Puget Sound Power and Light Co. will supply the power necessary for the street cars, after which time the city must provide its own power. Although the shutting down of the shipyards has temporarily decreased the power demand, yet the City Council believes that the one great necessity toward a healthy growth is in the matter of cheap power and plenty of it. The city engineers are working toward these ends, and are planning that when the projects now under way are completed power may be delivered to customers at an exceedingly low rate.

As the Skagit River project will take considerable time even to develop the initial power house (a spur railroad has to be built into a new country, practically) and power is not expected before January, 1923, several new means of supplying power are under consideration. One, the scheme of driving a tunnel from the Cedar Dam site to a new water power plant, is favored by J. D. Ross, superintendent of lighting. An earlier project, an increase in the existing steam-power plant on Lake Union, which is inside the city limits, is rapidly nearing completion. The original plant, built in 1913, was of 7,500 kw. and had an increase of 8,500 kw. in 1917. The present increase is of 75 per cent of the total plant.

The Lake Union plant, like many Pacific Coast steam plants built before 1914, uses fuel oil. Since that time oil has increased in cost several hundred per cent, but more serious than anything else is the lack of regularity of supply. Seattle, with its excellent coal mines but a few miles away, need not worry about its coal supply. The great success of the Western Avenue plant of the Puget Sound Power and Light Co., using pulverized coal, would seem to indicate a solution of the fuel difficulty should this become acute, although the cost of the change will be large.

The present steam plant on Lake Union consists of eight 8,250-sq.ft. Stirling water-tube boilers, designed for 200 lb. pressure with Foster superheaters capable of maintaining 125 deg. superheat. Each pair of boilers has its own self-supporting steel stack of 90 in. in diameter and 170 ft. high. There is one 7,500- and one 8,500-kw. Allis-Chalmers steam-turbine-driven generator of the same make designed for two-phase 2,500 volts. The condensers are of the Wheeler rectangular jet type. All pumps are centrifugal except the oil pumps, and the auxiliaries are turbine-driven except the condenser pumps, which are both turbine- and motor-driven.

The new plant is similar in nearly every respect to the old. It consists simply of six Stirling boilers of the same size and a third Allis-Chalmers steam turbine and generator, but for 250 lb. pressure and 125 deg. superheat. The turbine will run at 1,800 r.p.m. and 28½ in. vacuum. The generator is rated at 12,500 kva.

Performance Guarantees for a French Turbo-Generator

The guarantees for a 4,000-kw. turbo-generator set at present being erected in France may be of interest to American engineers in comparison with the performances of American-built machines.

The capacity of 4,000 kw. is based on a power factor of 80 per cent, which means that the capacity of the generator is 5,000 kva. The machine must carry 25 per cent overload on test for one-half hour and must develop 60 per cent of its capacity running non-condensing.

The steam consumption at various loads, subject to the following conditions, is:

Load	Lb. Steam per Kw.-Hr. Delivered to the Board
5/4	12.40
Full	12.34
¾	12.90
½	14.11
¼	17.63

The normal steam pressure is 170.7 lb. gage, and no allowance is made for pressures above. In case the actual pressure of the tests is less than the normal but greater than 128, the allowable consumption will be increased 0.105 per cent for each pound of difference.

The specified temperature of the intake water is 59 deg. F., but allowances will be made as follows:

Intake Temperature	Allowance
41 Deg. F.	Reduction 2.5 per cent
50 Deg. F.	Reduction 1.5 per cent
59 Deg. F.	No allowance
68 Deg. F.	Increase 2.8 per cent
77 Deg. F.	Increase 6.3 per cent

The total temperature of the steam is to be 617 deg. F. corresponding to a superheat of about 249 deg. F. An increase in the steam consumption of 1.4 per cent will be allowed for every 18 deg. by which the test conditions fail to equal the temperature specified.

In case the power factor is unity instead of 80 per cent, the figures are to be reduced.

It will be noticed that as the set is to be tested as a whole with condenser, auxiliaries and exciter, there is no vacuum specified. There is no correction for the power taken by the exciter, as this is mounted on the end of the shaft.

"Refrigeration Problems"

By Roland L. Tullis

The writer once took a position as engineer in a large creamery which contained refrigeration equipment of 100 tons' capacity. The plant consisted of two steam-driven ammonia compressors each of 50 tons' capacity, together with all the usual auxiliary equipment found in a refrigeration plant. It was what is termed a combination plant; that is, part of the refrigeration was accomplished by direct expansion, while the remainder was cared for by the circulation of brine, which had previously been cooled in a set of double-pipe brine coolers.

Brine was taken from the main brine tank by a large motor-driven centrifugal pump and forced through the double-pipe brine coolers under a pressure of 20 lb. per sq.in. After passing through the brine coolers the liquid was distributed to the cold-storage rooms throughout the building. There was a large number of cold-storage rooms used for the storage of butter, cheese, eggs, fruit, etc. No difficulty was experienced in holding these rooms at the desired temperatures by the circulation of brine. Temperatures in these rooms were usually held between 40 and 45 deg. F. or could be regulated as desired by the inlet brine valve.

By far the greatest amount of refrigeration was required for pasteurizing milk and cream. Pasteurization is accomplished by heating with steam to a temperature of 145 deg. F., then immediately chilling to a temperature of 45 deg. F. with brine.

Additional Load Caused Trouble

After this plant had been in operaton for some time the owners decided to operate an ice-cream manufacturing plant in conjunction with the creamery; consequently, half a dozen motor-driven ice-cream freezers were installed, and a small brine tank was constructed, to be used exclusively for freezing the ice cream; two large hardening rooms were constructed and equipped with direct-expansion piping and coils. It was soon discovered, however, that the addition to the plant was going to cause trouble for the operating force.

As soon as the hardening rooms and the ice-cream brine tank were put in operation it was almost impossible to hold the main brine at the desired temperature of 20 deg. F. or below. This temperature was required on the main brine tank in order to pasteurize the milk properly and cool the numerous cold-storage rooms throughout the building. It was desired to keep the hardening rooms at zero or lower in order to facilitate the quick hardening of the ice cream, which occasionally could be allowed to remain in the rooms for only a few hours. It was also necessary to hold the small ice-cream brine-tank temperature between 5 and 10 deg. F. in order to produce ice cream of the quality and quantity desired. The hardening rooms were located on the main floor, about fifteen feet below the main suction line to the compressors. This arrangement was the cause of a great deal of trouble, due to the trapping of liquid ammonia in the hardening-room coils.

The shift engineers in charge of the operation of this plant were about the usual type of steam engineer; that is, they had failed to make any special study of the theory or practice of mechanical refrigeration, consequently they were often unknowingly attempting to obtain more than was theoretically possible.

In order to hold the main brine temperature at the requred 20 deg. F. it was necessary to carry a suction pressure of 20 to 25 lb. on the compressors. It was also necessary to hold the hardening rooms below zero and the ice-cream brine between 5 and 10 deg. F. Therefore the engineer would open the expansion valves in the hardening rooms and on the ice-cream brine tank, but the temperatures refused to come down below a certain specified point regardless of how the expansion valves were manipulated. The engineer testified that he had opened the expansion valves until the suction line frosted back to the compressors, but the temperatures remained the same. By reference to a table of relative temperatures and pressures of ammonia it will be seen that ammonia under a gage pressure of 25 lb. will boil at 10.8 deg. F. Therefore a lower temperature at this suction pressure is utterly impossible. While in actual practice even the aforementioned temperature cannot be attained, therefore it will be seen that the only possible way to lower the temperature is to decrease the suction pressure; but in this case it was both impossible and inadvisable, as to decrease the suction pressure would decrease the capacity of the compressors, which were already heavily loaded.

A Separate Compressor Used

Finally the trouble was remedied by the installation of a small motor-driven compressor to take care of the hardening rooms and the ice-cream brine tank. By operating this small machine with a suction pressure of from 5 to 10 lb. it was possible to hold the hardening rooms below zero and the ice-cream brine below 10 deg. without interfering with the economical operation of the large units.

To avoid the expense of a separate complete installation the small compressor was connected to the system in such a way as to use the same ammonia condenser and liquid receiver as the large machines, the only difference being in the low suction pressure carried on the small machine. However, there was an auxiliary line which connected the suction of the small machine with the main suction. By opening a gate valve the three machines could be operated together if desired.

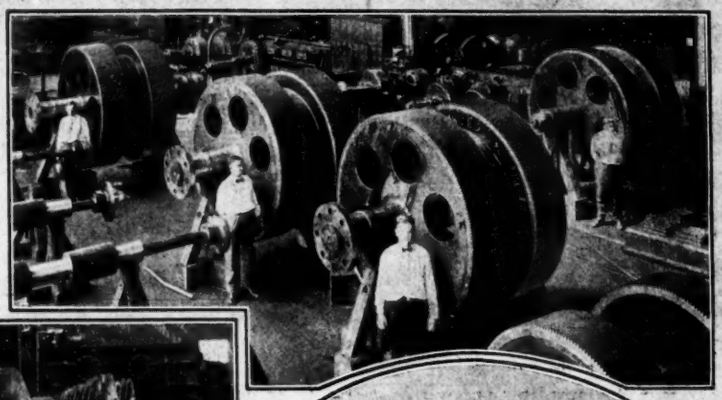
When the small machine was started and the expansion valves in the hardening rooms were adjusted properly to give a 5-lb. suction pressure the hardening-room temperatures soon dropped to 10 deg. below zero.

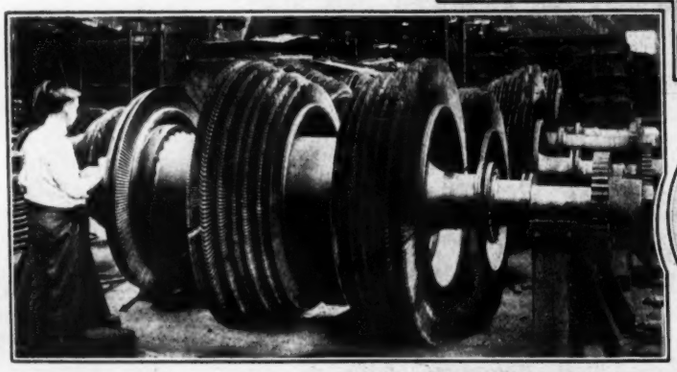
Now if the expansion valves in these rooms were not watched closely or shut off at the proper time the temperatures would continue to drop and all the ammonia in the system would soon become trapped in the hardening-room coils. In this way the hardening rooms would rob all the ammonia from the rest of the system. The keynote of successful operation in this plant was to keep the ammonia pumped out of the hardening rooms. If you suddenly discovered that the ammonia had disappeared from the liquid receiver you could look for low temperatures and consequent trapped ammonia in the hardening rooms. Occasionally it became necessary to open the doors and allow the temperature to rise in the hardening rooms (rise in temperature caused ebullition of the trapped liquid in the coils) and it could soon be pumped out. On a number of occasions the room temperatures dropped to 15 and 20 deg. below zero, and the coils were full of liquid which refused to boil on account of the low temperature. The main suction line being fifteen feet above the coils it was necessary to pump a vacuum on the machines to remove the liquid and get it back to the receiver.

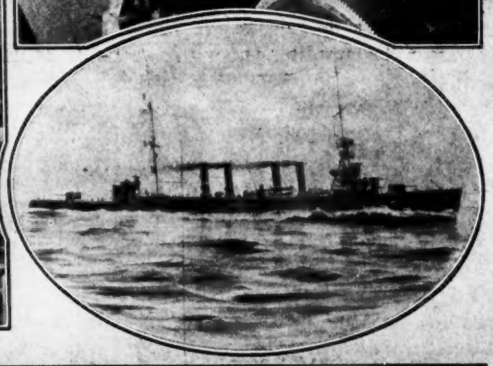
Right, turbine reduction gears for the new United States scout cruisers at the Westinghouse Shops. Each ship will be driven at a speed of 35 knots by four 22,500 h.p. cross-compound turbines.

In oval, one of the cruisers.

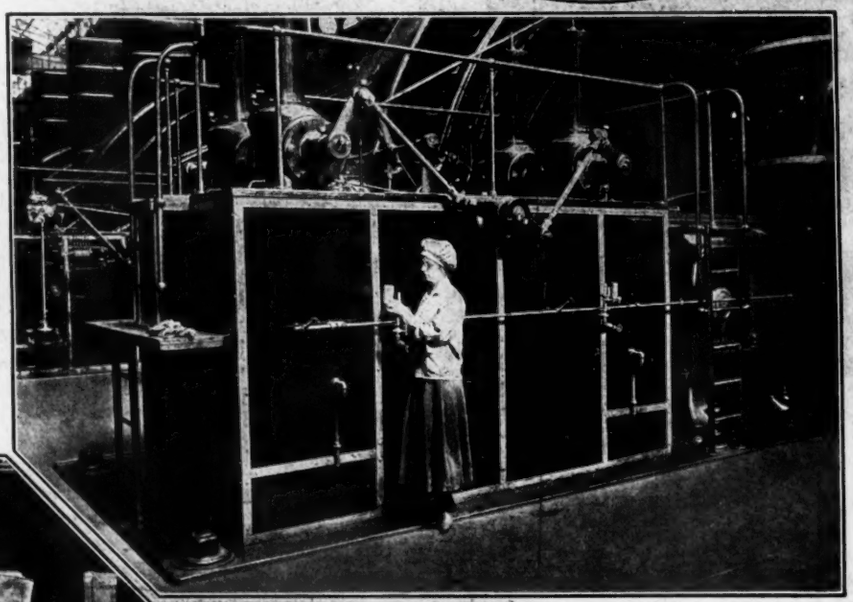
Below, one of the low pressure turbine rotors: each unit consists of a high- and low-pressure turbine and drives a propeller through one of the large gears.







A woman employee takes indicator diagrams on this big engine at the 59th St. powerhouse of the Interborough Rapid Transit Co., New York City. This machinery helps drive New York's subways.



These car couplings came to the Interborough Rapid Transit Co. in a shipment of coal, and quite naturally, broke the crusher. No wonder the subways demand a higher fare!

EDITORIALS

Shop Inspection of Boilers

THOSE interested in the purchase of boilers must appreciate the advantages resulting from the standards of good material, uniform design and careful construction, established by the A. S. M. E. Boiler Code. Likewise, the builder of boilers is confident a competitor cannot comply with Code requirements, and use unbranded boiler plate, full-punched holes and improperly fitting parts, in that way producing an inferior boiler that can be profitably disposed of at a lower price. The public and employees are better safeguarded when equipment is all that it should be, and the interest of the public is not so remote as first thought might indicate, when the sidewalk-basement boiler rooms, the department-store power plants and the demand of hotels for steam are considered.

There seems to be no disagreement as to the broad benefits from the work done by the Code committee, but the historical verdict will depend not so much upon the aims and objects of the Boiler Code as upon its practical application. The men to whom is intrusted the examination of the design, material, construction, installation and the operation of the boiler intended to meet specifications, must not only be capable of passing sound judgment, but also must have the inclination to do so.

At the steel mill the test engineer is, or should be, aware that the boiler inspector has no authority to accept as satisfactory, unbranded material, as Code paragraph No. 36 cannot be misconstrued, and such plate should be returned to the mill unless there remains sufficient of the original marking to clearly justify restamping. The boiler manufacturer is not being favored by the inspector who signs a state certificate for a boiler he did not examine during the process of construction. Likewise, the inspector who, to save a return trip to the shop, witnesses in his official capacity the placing of the code emblem and the state standard number and signs the certificate for a boiler no part of which has been tested hydrostatically, and which later is to be completed and tested by the employees of the builder, contrary to the provisions of the Code, is placing in jeopardy his commission and the boiler manufacturer's license for that state should the transaction become public.

The boiler manufacturer, his engineer or superintendent who seeks to influence a conscientious inspector to depart from the dictates of his better judgment, by insisting that similar favors have been extended by other inspectors, is creating a condition of ultimate benefit to his competitors, and by reason of such favors the whole plan of uniform boiler requirements may be defeated. The acceptance of an unbranded plate or in fact the use of a plate that was rebranded by the representative of the steel maker after all identification marks had been removed, the acceptance of questionable riveting or poor workmanship of any description, breeds within the inspector the "good enough" feeling which will destroy the man's judgment and cause an unmistakable decline in the boilermaking art.

All those interested in the safety of steam boilers are collectively anxious for the success of the A. S. M. E. Boiler Code, but it is necessary to consider the question from an individual point of view. While the steel manufacturer or boilermaker may suffer a slight financial loss when inferior goods are rejected, the production of a good boiler should be the goal. Those directing the work of the shop inspectors should establish the Code boiler, during the tradition forming period, on such a foundation that the public will understand the meaning of the Code emblem as clearly as is now understood the daily press headline, "The Marines Have Landed."

The Heat Pump

THE steam-power problem is fundamentally one of economy in the use of heat—first, to transmit as large a portion as possible of the total heat in the coal, burned in the furnace, to the water; then to get this heat to the source where it is used with the least possible waste; and third, to utilize it most economically, whether for power or for heating purposes. When the over-all thermal efficiency of the modern steam engine or turbine is considered, it is found to be very low, owing to the large quantities of heat that must be thrown away in the exhaust or condensing water. In heating and cooking, the thermal efficiency in a properly designed equipment is high, and where it is possible to combine the proper power and heating load one of the most economical combinations is obtained. Under these conditions the heat that is lost in the circulating water of condensing or the exhaust of noncondensing engines, is used for heating at the high thermal efficiency that is possible to obtain in such equipments. Unfortunately, conditions are such that the combined heating and power load can be taken advantage of only to a limited extent. In some industries the heating requirements are large and the power demand is small, or vice versa. In other cases the power and heating load do not synchronize.

In ordinary process heating, such as concentrating and boiling of liquids, the heat passes off in the vapor and is lost in one form or another. Attempts have been made to utilize the heat in these vapors for other heating purposes. Notable among these is the multiple-effect apparatus, where the vapor of a high-temperature vessel is applied to one requiring a lower temperature. Of course this scheme is limited to cases where process heating can be done at different temperatures.

In this issue is an article, "The Heat Pump in Theory and Practice," by Fritz Krauss, which describes a device that is creating considerable interest in Europe at the present time, and is intended to utilize the heat of evaporation over and over again, by making up the losses due to radiation, the fundamental idea being that when a pound of water is converted into steam, the heat required to do this is still available in the steam. If the heat in the pound of steam was given up to a

second pound of water, the latter would become steam and the pound of steam would be distilled to water. Then the heat in the second pound of steam could be applied to a third pound of water. If there were no loss of heat, a perpetual water distiller would be available of course; in practice there will be a heat loss due to radiation and the difference in temperature of the incoming raw water and the distilled water delivered. It is the purpose of the heat pump to make up these losses by compressing the vapor given off by the still. No doubt the heat pump is limited in its application, like all other heating equipment, and will find its widest use where coal is scarce and cheap power is available. Although we may not have arrived at a time where the heat pump can justify its application on an economical basis, nevertheless it offers an interesting study in thermodynamics.

Ammeter Shunts

IN THESE days of efficiency in the conservation of time, material, space and energy practice in the operation of direct-current power plants requires that the output be measured with reasonable accuracy, with all unnecessary errors eliminated; the space, material and energy losses must be reduced to a minimum necessary to secure and maintain this accuracy; in case of growth or change all the old material must be used whenever possible.

In order to comply with these requirements, the operator should know something of the theory and design of the apparatus in use. Shunts are an important factor in direct-current measurement, and many times will be heard the questions, "What are shunts?" "Why can they not be made of copper, or iron or brass?" "How is it possible to have errors in an apparently simple piece of metal?" "How can the proper shunts be selected?" On other pages of this issue is an article discussing this piece of apparatus, and a careful perusal should clear up many of the hazy points existing in the average operator's conception of shunts, measurements and errors.

Another point that is worth considering is the quick change that may be made in the measuring capacity of a station simply by changing the shunt. Many times the manufacturer of the apparatus is asked if a certain shunt can be used with a certain meter, or what old apparatus can be used in changing the capacity; and frequently the whole equipment of instruments, leads and shunts is discarded and a new outfit purchased, when a knowledge of the principles involved would have indicated that only new shunts were required and the expense of new instruments and their installation could have been saved.

Coal Wastage

COAL, the basic commodity of our civilization, has received less efficient attention than anything else we use in common everyday life. Beginning from the time the coal is taken out of the ground the crudest and most wasteful methods are used. Only about one-half of the coal in the mine is recovered for useful purposes. Of this fifty per cent which finally reaches the surface a certain amount is used in generating power to produce the coal and another proportion of this coal is in such a finely divided state that it is practically useless for commercial purposes, so that the percentage of the coal originally existing in the ground which reaches the consumer is indeed small.

What would be thought of a gold or copper mine in which one-half the metal was not recovered? There are metal mines in the West where the tailings contain less than one per cent of metal, and they are being worked over at a profit to reclaim this metal. Many years have passed in this country without much progress being made toward reclaiming the large quantities of wasted coal lying at the mouth of the pits. The same crude processes follow the coal all the way through the industrial world. Methods of burning are not what they should be when we consider the time that has been spent in developing the mechanical arts since the days of James Watt.

Much of the coal that is burned should not be used in the raw state, as the byproducts that can be recovered are more valuable than the coal itself. Moreover, we are burning up rapidly the choicest coal in the country, leaving untold millions of tons of the lower-grade coals undeveloped. These choice coals are richest in those products which should be reclaimed, and when once burned all is gone forever. On the other hand, the low-grade coals, which are widely distributed, do not have the rich volatiles. If any coal is to be burned in the raw state it is more nearly justifiable to burn them.

The lignites, which will be our ultimate fuel supply, are not well adapted to use in the natural state. They do not stand transportation or storage, and much has to be done before they can be considered as staple fuel.

Accept Improvement; Don't Wait for Novelty

IN MATTERS of fashion the ladies must, of course, have the latest style or things are not at all well with them. However, in more matter-of-fact every-day affairs fashion is usually of much less importance than effectiveness. This is undoubtedly true in power-plant design and operation. It is far better to utilize the good ideas that others have been able to profit by than to delay until some entirely new device or system may be evolved by an Edison or a Fulton. This, of course, does not mean that one should frown upon novelty; but to wait for novelty is foolish.

Moreover, it is not worth while to wait to learn of improvements for the plant until something new turns up. One of the most effective and pleasant ways in which to secure these and to profit by acquaintanceships is by making a visit to the other fellow's plant. Go frequently to see just how he is "getting results," and if he has something worthy of imitation go home and apply it at once. Take advantage of the late improvements, the "kinks" that save a few pounds of coal or a few minutes' time each day. The aggregate of these improvements will often be tremendous.

And then, too, when you have a good idea yourself and find that it really works in practice let your friends share in your advances. This is a responsibility you owe them. Only by such co-operation between the thousands of plants can the advance of the power-plant engineer be most rapid. In this particular phase of plant improvement *Power* undertakes to serve to the full. But this service cannot be "one hundred per cent" perfect without the co-operation of every reader who himself has achieved improvement of any sort. Prompt publication of your achievements helps all, and through it all may share the little advances which can be made so inexpensively, but which contribute so largely to safe, economical and comfortable operation.

CORRESPONDENCE

Operation of Three-Phase Motors on Single-Phase

Trouble occurred in a group of seven three-phase 440-volt motors, all fed from the same feeder. It was reported that any one of these motors would start and come up to speed all right, but would slow down as soon as load was applied. Upon further inquiry it developed that this was the case only when at least one other motor was already running off that feeder; that the first motor had to be started by hand. As was to be expected, I found one fuse blown on the feeder cutout, and after this fuse had been replaced the motors gave no more trouble.

The explanation of this action is as follows: The first motor acted as a single-phase machine and had to be started by hand. When up to speed, however, it operated as a rotary phase-converter, or single-phase induction motor and three-phase induction generator combined, thus supplying voltage of approximately the right value and correct phase relation to the line whose fuse was blown. This enabled the other motors to start up as three-phase motors. When load was applied, however, the power had to be supplied by the line from one phase alone, the voltage became unbalanced, and the speed dropped off. E. S. BAXTER.

Boston, Mass.

Design of Hogged-Fuel Furnace

I read with interest the article by G. L. Baldwin in the Dec. 21, 1920, issue of *Power* on the design of a hogged-fuel furnace. I observe, however, that the drawing accompanying the article was not made to scale. For instance, the height of the furnace is given as 4 ft. as marked on the diagram and the length of the grate as given in the text is 9 ft., whereas if we take the scale for the height as 4 ft. the length as indicated is something over 12 ft.

I should like to ask Mr. Baldwin if this design of furnace is smokeless. To my mind the throat and the space between the bridge wall and the bottom of the boiler are too small for the size of the grate used, and I believe that much better results could be obtained with a wider throat and this space materially increased, which would allow a slower passage of the gases and give a better opportunity for them to be consumed before reaching the rear end of the boiler.

No information is given as to the number and size of tubes in the boiler, but assuming that they are 3-in. tubes the boiler would have approximately 1,840 sq.ft. of heating surface. On this basis there would be 34 sq.ft. per square foot of grate surface. I have a boiler with 2,550 sq.ft. of heating surface using only 56 sq.ft. of grate surface, or 45.5 sq.ft. of heating surface of grate area. This is only a rough idea, because the actual capacity of this boiler has been equivalent to about 4,850 sq.ft. of heating surface—this with hogged fuel and with practically no smoke, the boiler having 16-ft. tubes.

I would like to ask another question not connected directly with the use of hogged fuel. What is the greatest distance of which any *Power* reader may know between a horizontal return-tubular boiler shell and the grates where economical results have been obtained? My reason for asking this question is that I started in setting boilers 34 in. above the grate and have been raising them until I have got them up to 5 ft. above the grate with improved efficiency with every inch in rise, and I am anxious to know if anyone has gone beyond this and still obtained good results.

Boston, Mass. HENRY D. JACKSON.

Labor Saving in the Plant

In the Dec. 28, 1920, issue of *Power*, page 1025, the editorial, "Labor Saving in the Plant," goes straight home to many steam plants. Here where I am the inefficiency of labor was plainly shown during last summer. The coal is thrown from cars into the boiler room, and I have seen two men for five days unloading a 50-ton car. These men were drawing $5 per ten-hour day, which made the cost of unloading the car $50, or $1 per ton. From figures I keep the average was $30 per car.

We have six boilers, each having 1,500 sq.ft. of heating surface, and to get away from the poor efficiency of labor the company put in a track-hopper feed elevator and conveyor. The first day I ran it, Jan. 5 of this year, I put 70 tons of coal into the boiler room in just one hour and a quarter, this being done without any extra labor and using the boiler room helper to dump the car and watch the feed.

The company has also put a coal crusher and elevator at the producer plant to do away with the high cost of labor, and they have put in mechanical clay feeders on all grinding pans in the mill to further do away with inefficiency in the way the pans were fed. I have found the pans require 35 hp. each if fed right, but have taken indicator diagrams showing a pan taking 50 hp. This might last for thirty minutes and then it would run empty for perhaps the same period. A. C. LINDON.

Blacklick, Ohio.

A Tank-Gaging "Stunt"

In gaging our fuel-oil tank, we experienced considerable difficulty in getting accurate measurements, because there was a flat heating coil just below the manhole on which the gage pole would rest and frequently cause an error of about six inches in the measurement, which resulted in a confusion in the

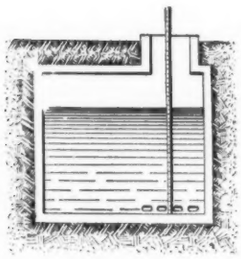


FIG. 1. OLD METHOD OF GAGING

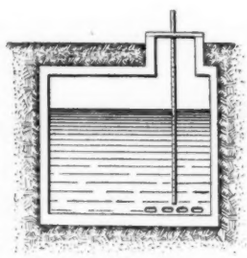


FIG. 2. NEW METHOD OF GAGING

FIG. 3. CROSS-STICKS

records. It was necessary to have the heating coil near the suction line to the pumps, therefore it could not be moved. It was difficult to make sure that the gage pole was really on the bottom and not on one of the pipes; so we resorted to the method illustrated. Fig. 1 shows the general layout and illustrates the usual way of gaging, together with the trouble encountered.

Fig. 2 shows how we remedied the situation by sawing off the bottom of the gage pole and hanging it from the top. Two crosspieces of strap iron, just long enough to reach across the manhole, were fastened to the gage pole at the height where they would just touch the top of the manhole when the pole rested on the bottom. This was determined by placing the pole as shown in Fig. 1, laying the crosspieces in place and marking the correct position. Fig. 3 shows how the strap iron is dovetailed in place enough to prevent its moving without weakening the pole. The two strap irons should be bolted together near the end with a spacer, to make them firm.

After all this has been completed and its correctness checked, the bottom six or eight inches are sawed off and the pole hangs free, as in Fig. 2. Used in this way, there is no chance for an incorrect reading, for there is nothing for the pole to hang on, and if it should hang, it would be detected because the crossarm would be above the manhole.

To keep out rain and trash, we made a loose-fitting tin cover with a hole just large enough for the gage pole and found that it added materially to the cleanliness of the place.

L. R. GRAY.

Wichita Falls, Tex.

Steam Making with Fuel Oil

The correspondence on page 113 of the Jan. 18 issue under the title, "Steam Making with Fuel Oil," by George S. Blankenborn, has arrested my attention. It has been my experience to handle a fairly large boiler plant composed of small units that were originally coal fired, but were remodeled for oil burning. I know nothing about coal or oil conditions on the Pacific coast, only as I read of such, but I know that the modern stoker-fired plant, consisting of large units and at the present-day prices of coal and fuel oil on the Atlantic coast, can show the oil-fired plant its heels as to cost of evaporating a thousand pounds of water.

In one large plant the difference in the cost of labor between coal and oil burning is not so great as to cause much alarm. Really the one item that favors oil is the ash question and the great difference in over-all efficiency at present enables the coal-operated plant even to forget the ash problem.

We know that oil at four cents a gallon should equal, in heat value, coal at $8 a ton. But when the Oil Baron says eight cents a gallon and coal of equal heat value is selling for $10 a ton, where does the fuel-oil plant fit?

During the war coal and oil prices ranged so nearly on a par that the oil plant in many cases had the better of the argument, but it would seem that oil is climbing and coal sliding back to nearer its normal level.

I believe, as Mr. Blankenborn suggests, that the true facts of the mentioned case should be learned by *Power* and published. We should burn the fuel that is best suited to our needs, whether oil or coal, and if one is cheaper in the East or the other is cheaper in the West, be satisfied to substitute, if possible and make power for the least cost.

C. W. PETERS.

New York City.

Sewing Up Cracks in Water Leg of a Boiler

The repairs under consideration were made on a combination fire-tube boiler of a design that is no longer manufactured. The water legs of this boiler are steel castings. The front and rear sheets of each leg are braced against the pressure on their inner surfaces by web stays which span the space between the sheets as integral parts of the casting.

The boiler had been in service about two years when a crack running from one of the tube holes in the

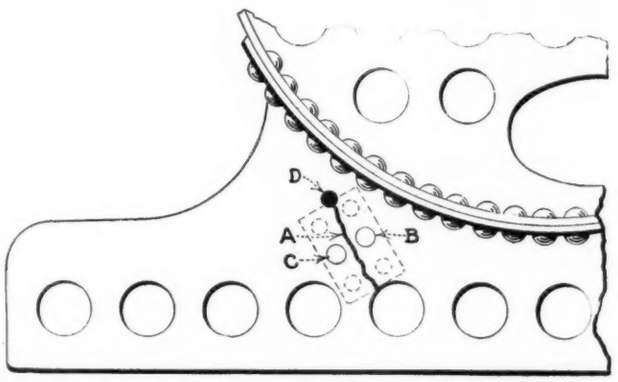


FIG. 1. SHOWING POSITIONS OF CRACK AND RUST PATCH IN REAR SURFACE OF WATER LEG

rear surface of the front leg was first noticed. To prevent extension of this crack, a hole was drilled, tapped and plugged with a ¾-in. copper patch bolt at the extremity of the crack, as shown at *A* in Fig. 1. Two holes, indicated at *B* and *C*, were then drilled and tapped through both the front and rear surfaces, and 1⅛-in. steel staybolts were screwed through. The staybolts were put there simply to impart rigidity to the plate on each side of the crack. To prevent leakage, a rust-patch, made with iron lathe turnings and salt-

peter, was fastened on the outside of the plate, as indicated by the dotted lines, with four ¾-in. copper patch bolts. This, however, failed to hold. After much further unsuccessful experimentation with the rust patch, the engineer concluded to sew up the crack, as indicated in Fig. 2.

A $\frac{31}{32}$-in. drill was centered in the crack close enough to the patch bolt at *D* to cut a small segment out of this bolt. The drilled hole was then tapped, and a ¾-in. copper patch bolt was screwed in, upset and driven and trimmed off flush with the plate. A second hole was then centered, drilled and plugged in like manner. And so the job proceeded until the crack was sewed up to the tube hole. The thread of the last hole in the row barely cut through into the tube hole. The spacing of the centers, as the drilling proceeded, was so adjusted as to produce this result. The protruding thread was then filed down so as to restore the true periphery of the tube hole.

Shortly after the completion of this repair a crack was found extending between two adjacent handholes in the front surface of the same water leg, as indicated in Fig. 3. This, however, was permanently repaired by means of the oxyacetylene welding process.

But another crack, which later on developed in the same sheet, did not yield so readily to the oxyacetylene treatment. This crack is also shown in Fig. 3. The welding process was applied three different times. The first and second attempts failed, each time as soon as the boiler was fired up to go into service. On each of these occasions the crack opened up to its initial proportions. On the third attempt the crack reopened, when the boiler was fired up, to a depth of about one-quarter the thickness of the sheet from the inner surface. The appearance of the metal where the original crack ran into the handhole and out at the edge of the saddle, indicated this condition.

To compensate for the diminishment in strength, two holes were drilled and tapped on each side of the weld, through both the front and rear surfaces, for

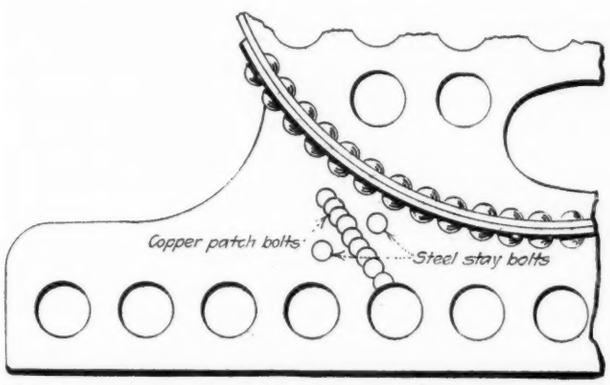


FIG. 2. CRACK SEWED UP WITH COPPER PATCH BOLTS

the insertion of $1\frac{1}{16}$-in. copper staybolts. As security against leakage at the handhole end of the crack, a ¾-in. copper patch bolt was inserted at this end. The hole for this bolt was so centered as to cause the tap to run out slightly into the handhole. Then, when the bolt was inserted and upset, its protruding side was filed down so as to restore the curvature of the tube hole.

When the contour of a steel pressure vessel, as the water leg in the present case, is a blending of flat with curved surfaces having different degrees of curvature, it should be formed of wrought plates riveted or perhaps welded together, instead of being cast in a mold. At any rate one might be warranted in adopting this opinion after viewing the behavior of the construction shown. Cooling, in the mold of a thin-walled casting having this shape must inevitably result in producing permanent shrinkage stresses in the metal.

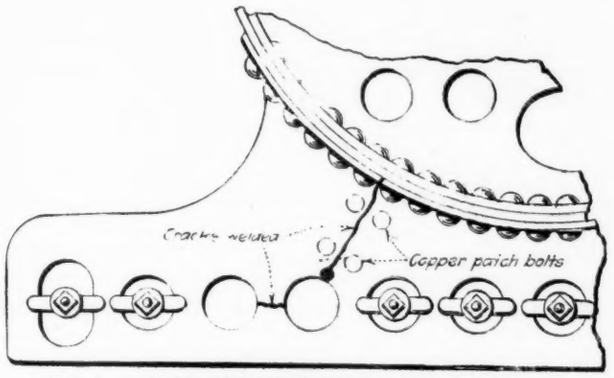


FIG. 3. CRACK REPAIRED IN FRONT SURFACE OF WATER LEG

The intensity of such stresses being unknown, the factor of safety against subsequent rupture of the walls of the vessel is always problematic.

A. J. DIXON.

St. Louis, Mo.

Some Elevator Troubles

One of the passenger elevators in our plant developed a disagreeable vibration, which continued to grow worse. Evidently, this vibration was transmitted through the cables from the hoisting mechanism to the car. I was told that it had existed from the time the machine was put in service, the elevator having been accepted from the contractors in this condition. The explanation was that the vibration was due to a little roughness of the worm or gear, which would soon wear itself smooth, and then the vibration would cease. On the contrary, the vibration grew gradually worse until it became a nuisance.

Opinions varied as to the direct cause, some holding that the worm meshed too deep into the worm gear and ran on the bottom of the gear teeth. Others were of the opinion that the wormshaft was bent. My own belief was that the face of coupling, which also formed the brake wheel, was not at right angles to the axis of the wormshaft. I wanted to bolt both wormshaft and armature together and swing them on a lathe's centers so as to test for concentricity. Finally, it was decided to hand the job over to the original contractors and let them remedy the trouble. They removed the fault for the time being and claimed to have found a loose bearing in gear case next to the brake and armature coupling. This bearing was rebabbitted and, as stated, removed the trouble for a time. I am still skeptical, however, and think the loose bearing was a result and not the cause, because there is a gradual return to old conditions.

A temporary remedy, which may be of interest in passing, was to press the two main car cables together at a point about two feet above the car crosshead and tie them with two turns of ordinary belt lacing. The lacing seems to "give" enough to absorb nearly all the car's vibration.

D. A. MANSON.

Washington, D. C.

Firing Steam Boilers with Fuel Oil

There have appeared in the columns of *Power*, from time to time, articles on fuel-oil burning under steam boilers. While these articles were good for the technical man and well-versed engineer and fireman, they seem to lack what is needed at the present time, at least in this section of the country, where so many power plants are changing from coal to fuel oil. As there are not enough experienced firemen for oil-burning plants to supply the demand, many will have to use men who have had no experience in firing with oil. Therefore the following may be of help.

The boiler furnace should be lined with the best obtainable firebrick and all set as headers; that is, the brick should be placed with the ends to the fire so that they will better resist the small explosion shocks without breaking or cracking. These small explosions are caused by some of the gases in the oil having a higher igniting point than others. Some oil gloubles will not be atomized as fine as others, and the larger ones will burst and set the gases free. Thousands of these small globules are partly carbonized and explode, sometimes with considerable force. As the fire is controlled by the amount of oil fed to the furnace, one is likely to over-fire the boiler when heavy loads come on suddenly. This is very severe on the furnace, even if the forcing lasts but for a short time until another boiler can be brought into use.

The oil pumps should be put where they can be looked after easily and kept in good order, as their failure would cause a shutdown. Oil pumps must be equipped with a governor to insure a steady oil pressure. If the oil pressure fluctuates, it will cause the burners to puff with every stroke of the pump.

A burner must be selected for the special needs of the plant. A burner giving a flat flame that will distribute the fire evenly throughout the furnace is the most satisfactory. When steam is used to atomize the oil, there should be a regulating valve in the pipe line to insure an even steam pressure at the burners. Steam at 150 lb. pressure has given the best results, in my experience. The oil pressure should be 100 to 115 lb., and the temperature of the oil should be between 170 and 180 deg. F. for the best results. Oil at a lower temperature will burn, but not so economically as at the higher temperature, as it must be a gas or as near a gas as possible to get it to obtain proper combustion.

If the heating of the oil is not done by the heater, which must be placed between the pumps and the burners and before it enters the furnaces, it must be done by the heat in the furnace, and this often causes a black smoke, which is unburnt oil and gases that would have given off heat if properly ignited.

Black smoke will also be caused by the flame of two burners striking each other when two or more burners are placed under one boiler in the same furnace. It is always best to have a dividing wall part way if not all the way across the furnace. If the flame strikes the furnace side walls, black smoke will result. The burners should be adjusted to throw the flame toward the center of the furnace.

Baffle walls should be kept in good order, also the spatter or target walls that are used to break the flow of gases and flame. It is best to have the burners throw the flame toward the front of the furnace.

Care should be taken in getting up steam on a cold boiler as an intense heat can be obtained, which if not handled with care, may burn the tubes or the shell of the boiler or ruin it by unequal expansion. After cutting out an oil-fired boiler, close all dampers and draft doors to save the brickwork and boiler by holding the heat in the furnace and so prevent its cooling too quickly.

One may have trouble in keeping the oil ends of pump rods packed. I have found asbestos packing the best kind, as the acids contained in the oil do not deteriorate it.

Do not permit smoke to issue from the chimney. If the fire is smoking, something is wrong; look it up and remedy it at once, because if the fire is smoky the boiler tubes will become coated with soot in a few minutes. If more oil is fed without remedying the trouble, it only makes matters worse. FRED E. CUPPER.

Jacksonville, Fla.

Data on Motor Operation

Referring to Mr. King's inquiry in *Power* on Jan. 18, on relay setting for induction motors, it would seem that his trouble results from a lack of protection against single-phase operation. The ordinary overload relays usually furnished with such equipment are arranged for setting from 25 to 50 per cent overload. If the relays are in the starting circuit, they may trip out when starting the motor if the time setting is not sufficient to delay the operation.

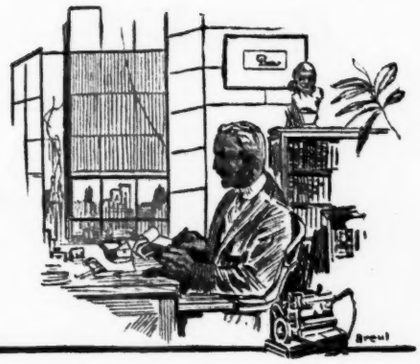
In some installations the relays are so connected that they are not in the starting circuit and are energized only when the switch is in the running position. In this way the setting of the relay can be reduced to near normal and the time delay made small, as the relay is not subjected to the heavy starting current. Of course, with this connection the relays give no protection during the starting period. If the relays are in the starting circuit, they can be set for 25 per cent overload, and the time delay adjusted so that the relay justs fails to trip out in starting. This will allow the relay to operate under ordinary overloads in a minute or two, which is ample protection to the motor.

If the motor was running at full load and one phase was opened, the load on the remaining phase would be increased to approximately 173 per cent. A setting of 25 to 50 per cent overload for the relays would cause them to operate under this condition.

There are some cases when it is thought that overload relays do not give adequate protection against single-phase operation, and relays known as the balanced type are used. Such a relay has three current coils and trips out the switch if any circuit is opened or if there is any great unbalance in the three lines. Relays with potential coils for this purpose have also been designed. In some cases, however, there may be a three-phase voltage maintained by the motor, even if one phase opened and the motor was running single phase. In such a case the voltage on the open line would be induced by the motor, and a relay with potential coils might not operate if the voltage was nearly balanced. If the rewinding of Mr. King's motors is due to single-phase troubles, the manufacturer of the motors should be consulted, as it would seem that the rewinding costs could be reduced to a large extent if the trouble is due to single-phase burnouts.

Milwaukee, Wis. HOWARD D. MATTHEWS,
Head Dept. of Elec. Eng.,
School of Engineering of Milwaukee.

INQUIRIES OF GENERAL INTEREST



Single Riveting of Vertical Boiler Furnace Sheets—Why is single riveting considered to be sufficient for the furnace-sheet joints of large vertical boilers? J. J. H.

The shell of the firebox is subjected to a collapsing pressure which is resisted by staybolts that pass through the water leg to the outer shell, and when the staybolts have proper strength and spacing, the riveting of the longitudinal joint of the firebox sheet has little more to perform than to hold together the laps of the joint for calking.

Piston Ring for 12-in. Steam Cylinder—What should be the size of outside diameter for turning a cast-iron piston ring for a steam-engine cylinder 12 in. in diameter? E. M.

For a finished ring of about $\frac{5}{8}$ in. thickness and made of a good quality of close-grained cast iron, the outside should be turned off to $12\frac{1}{4}$ in. diameter and have $\frac{3}{4}$ in. cut out of the circumference, or simply cut square across with the ends finished to form a half lap-joint $\frac{3}{4}$ in. long and width equal to the radial thickness of the ring, so the plane of the joint will be parallel with the flat sides of the ring.

Independent Exhaust Lines for Diesel Engines—We have two Diesel engines, each of 200 hp. Cannot both exhaust into a common exhaust pit relieved by a single exhaust pipe extended up alongside of our main building? S. F.

It is preferable to have an independent exhaust pit and exhaust line for each engine. When the exhausts are connected, the products of combustion backed up from an engine in use have a bad corrosive effect on one that happens to be standing idle, besides being a source of interference when it is desired to inspect, adjust or repair one of the engines while the other is in use.

Otto and Diesel Cycle Efficiencies—Considering the Otto and Diesel cycles for internal-combustion engines, which is the more efficient? D. H. W.

The efficiency of the Otto cycle may be written,

$$e = 1 - \frac{1}{r^{k-1}}$$

when r is the compression volume ratio and k the ratio of specific heats, about 1.35. The Diesel efficiency is,

$$e = 1 - \frac{1}{r^k - 1}\left(\frac{p^k - 1}{k\,(p-1)}\right)$$ when p is the cutoff ratio.

The term in the brackets is always more than unity. Consequently, for equal volume ratios the Otto cycle is more efficient. Practical considerations prevent the employment of the Diesel ratio in the Otto-cycle engines and the Diesel engine as built is the more efficient.

Temperature for Mixture of Steam and Water—If five pounds of dry steam at a pressure of 5 lb. gage are mixed at atmospheric pressure with 10 lb. of water at 60 deg. F., what would be the temperature and condition of the resulting mixture? F. B.

One pound (weight) of dry saturated steam at the pressure of 5 lb. gage or 20 lb. absolute contains 1,156.2 B.t.u. above 32 deg. F., and five pounds of such steam would contain $1{,}156.2 \times 5 = 5{,}781$ B.t.u. above 32 deg F. A pound of water at 60 deg. F. contains $60 - 32 = 28$ B.t.u. above 32 deg. F. and 10 pounds would contain $28 \times 10 = 280$ B.t.u. above 32 deg. F. Mixing the steam and water together would make a total of $5{,}781 + 280 = 6{,}061$ B.t.u. above 32 deg. F., and a total weight of 5 lb. steam + 10 lb. water = 15 lb., and each pound of the mixture would contain $6{,}061 \div 15 = 40.4$ B.t.u. above 32 deg., so that the temperature of the mixture would be $40.4 + 32 = 72.4$ deg. F.

Calibrating Ammeter Shunts—In calibrating large shunts, is it possible to figure accurately the material to give a desired drop instead of filing or milling off a little at a time and taking a reading each time? R. T.

After a shunt is built up and tested, to determine the drop at its rated current it is easy to determine how much metal must be milled or filed off to give the desired drop, especially if the shunt be composed of manganim plates, as is usually the case. Assume a shunt in which the plates are exactly five inches wide. The length of the plates and their number is immaterial to this calculation. Suppose this shunt gives a drop of 95 millivolts at the rated current and it be desired to increase the drop to 100 millivolts. Divide the plate into 100 imaginary divisions; if all but one division be removed and the current forced through this one division, the drop will be 100 times greater, or 9,500 millivolts. If 95 of these imaginary divisions be left in parallel, the drop will be 95 times less than through one, that is, 100 millivolts. Therefore if it be desired to increase the drop from 95 millivolts to 100, we must cut off 5 per cent of the width of the shunt. In this particular case, the width must be cut down to 4.75 inches.

Superheated Condition for Reduced Pressure—On a steam line that carries dry saturated steam at 100 lb. gage pressure, I have placed a reducing valve to reduce the pressure to 20 lb. Will the steam delivered to the low-pressure side be superheated? E. G. G.

Neglecting the heat lost by radiation, a given weight of steam discharged through the reducing valve will contain as much heat as it had before passing through the valve. A pound of dry saturated steam at the pressure of 100 lb. gage, or 115 lb. per sq.in. absolute, contains 1,188.8 B.t.u., and a pound of dry saturated steam at the pressure of 20 lb. gage, or 35 lb. per sq.in. absolute, contains 1,166.8 B.t.u. Hence, without loss of heat in passing through the reducing valve each pound would contain $1{,}188.8 - 1{,}166.8 = 22$ B.t.u. more than necessary for a saturated condition at the reduced pressure, and therefore the steam would be in a superheated condition for the reduced pressure. Referring to tables of the properties of superheated steam, it may be seen that for a pressure of 20 lb. gage, or 35 lb. per sq.in. absolute, and a heat content of 1,188.8 B.t.u., the temperature would be 303.7 deg. F., and as the temperature of dry saturated steam at the pressure of 20 lb. gage is 259.3 deg. F., the steam would be superheated $303.7 - 259.3 = 44.4$ deg. F.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Heat, Light and Power for the Metropolitan District of New York*

By WILLIAM BARCLAY PARSONS
Consulting Engineer, New York City

THE long and wasteful series of wars that began during the French Revolution and ended twenty years later at Waterloo, left Europe struggling under an appalling mass of debts, with commerce and business dislocated. The world then was rescued from its predicament by the astounding application of steam power to all forms of industries and transportation. The productivity of human labor was so increased that a new order of things was created. Not only were nations able to care for their debts supposedly not payable, but they entered on an era of prosperity that continued substantially unbroken through the century. We are facing today a somewhat analogous situation.

The Twentieth Century cannot hope to repeat the experience of the Nineteenth. Any such revolutionary expedient as the supplanting of hand labor by mechanical power is impossible, but is it not possible to extend the application of power and especially to extend it in a more economical form to increase the effectiveness of human labor and so overcome the wastage of war? If so, the burdens of the war can be carried in a manner that will not press down men and industry.

Growth of Power Demand

The growth of central power stations of late is indicative of what is to be expected. In the State of New York, exclusive of New York City, there were installed in central power stations and electric-railway stations in 1910, approximately 550,000 hp., while in 1919 there were 1,150,000 hp. In the Metropolitan District—that is, New York and the adjacent territory in New Jersey, which it is convenient to treat as a whole—the installation on the same dates amounted to 920,000 hp. and 2,100,000 hp. respectively, giving totals for the state, including the Metropolitan District, of 1,470,000 hp. in 1910 and 3,250,000 in 1919. From these figures it will be seen that the increase in installed capacity has been at the rate of more than 120 per cent in nine years for the Metropolitan District and only slightly less for the remainder of the state. In a study of the power requirements of this territory now being made, the author, in order to be conservative, has placed the probable installed capacity in 1930 at 6,700,000 hp., of which 4,500,000 hp. will be in the Metropolitan District and 2,200,000 hp. "up state," an increase of about 100 per cent.

Translating these figures into dollars and estimating the cost of installing a steam-producing horsepower at $100, and water-producing power at $200 including transmission, there will be required during the next ten years in the state new capital for central stations and transmission lines, exclusive of the cost of appliances for utilization, to the amounts of $350,000,000 and $700,000,000 respectively. These estimates agree fairly well with those recently stated in an electrical paper that, during the next five years there should be similarly expended in the United States a sum of money between $2,000,000,000 and $4,000,000,000. Such figures are appalling, but they must be faced and met or the industrial development of this country will suffer.

Increased Cost of Coal

It was not long ago that coal could be bought in New York City for $2.50 to $3 a ton, delivered. Putting aside as abnormal the present price of coal, careful and hopeful buyers make $6 the lowest figure safe to consider as probable. If that be true, remembering that fuel represents three-fourths of the cost of producing current, it is obvious that if a fair return is to be had on an investment of $350,000,000, a charge must be made for current considerably greater than what has heretofore existed. If a fair return cannot be had, the investment will not be made and industry will suffer.

To avoid the dilemma of higher prices or lack of fair returns on investments, recourse must obviously be made to some other method of producing our central-station energy The alternative that first comes to mind is water power. Fortunately, New York State is particularly well favored in this regard, its potential resources exceeding all except the Pacific States.

The total amount of hydro power that can be obtained in New York provided the Niagara be fully utilized and the scenic effect be destroyed and that one-half that portion of St. Lawrence power contiguous to New York State be considered will not exceed 4,500,000 hp. But public opinion will not permit the full utilization of Niagara, at any rate not until the demand for new sources of power is more imperative than it is at present. Complete development of the St. Lawrence is also likely to be postponed for many years, so that New York's actual undeveloped sources in sight can be put as not exceeding 1,500,000 hp. It has already been shown, with a very conservative estimate for additional power installation, that before the end of the present decade there will be needed about 3,500,000 hp. It is, therefore, obvious that much of the power installation that can be expected in the near future will be of the steam-electric type with the attendant high cost of operation.

The amount of power that can be developed under any one of the four heads recited would be in excess of any demand by immediately adjacent markets. To take care of such excess and to assure a supply for all the needs of the industrial centers in the interior of the state between Albany and Rochester, arrangements must be made for a grouping of markets and transmission of power to distant points, including the Metropolitan District.

Frequencies in Use of Power Systems

Heretofore, in this paper, central power stations have been treated as of one type. Unfortunately, such is not the case. Leaving out of consideration a few odd frequencies which are local in character and negligible in amount, it is found that the installations in New York State are divided as follows:

Frequency Cycle	Horsepower Installed
60	700,000
40	150,000
25	1,950,000

Unfortunately, these variations in frequency are scattered throughout the state. Although 25 cycle frequency is that at which the Niagara current is generated, nevertheless in New York City this same frequency is the basis on which the greater part of the current is generated, the figures in New York City being:

Frequency Cycle	Horsepower Installed
60	280,000
25	1,450,000

The 40-cycle frequency is found as a general thing in the territory adjacent to and extending from Albany, westerly, as far as Utica, but in this same territory there is to be found side by side with the 40- a large amount of 60-cycle current. A study of growth seems to show that 60-cycle power is increasing at a much higher ratio than either of the others. It is likely that within a comparatively short time the 40-cycle systems will be eliminated and the state development will be confined to the two frequencies of 60 and 25. In New York City all the power generated at 25 cycles is converted to direct current for utilization. With the present state of the art there seems to be no reason why all this current could not be generated at 60

*Paper presented before the New York Section, American Society of Civil Engineers, Feb. 6, 1921.

cycles as well as 25, except for the fact that the present equipment is arranged for conversion from 25-cycle alternating current to direct current.

In that part of New Jersey included within the Metropolitan area, the situation is different. Here the 60-cycle predominates, the installation being:

Frequency Cycle	Horsepower Installed
60	250,000
25	60,000

It is on the Metropolitan District that the burden of furnishing new installation will fall. Of the estimated 6,700,000 hp. of installation that should be in existence in 1931 to meet the expected demand, 4,500,000 hp. will be found within a distance of thirty miles from the Engineering Societies Building.

The Metropolitan District is not only the largest aggregation of population in the United States, but it is also the largest center of manufacturing. Here will be found one-twelfth in value of the total manufactured production of the country—an amount greater than that of the whole state of Pennsylvania. In this area, demands for service are so much more exacting than in any other part of the state, that any interruptions of service cannot be tolerated. Service in New York City must be continuous. To this end the distributing companies have assumed the burden of great capital investment in placing all their transmission wires in underground conduits where they are as free from outside interruptions as is possible for human ingenuity to devise. Duplicate lines, several generating stations, and a great reserve of power guarantee continuity of service. Besides continuity there must also be a readiness to meet sudden and unexpected demands.

Peak Power Loads in New York City

The Metropolitan District, and particularly the lower part of Manhattan Island, has its normal times of peaks varying somewhat with the season; but unlike other districts, an excessive peak may occur at any time and at any hour, due to thunderstorm effects. The sudden darkening of the skies drives those living along our cavernous streets to the turning on of lights and to such an extent as to cause a peak greater than a normal one and one that may be hours out of time. This involves the maintenance of stand-by plants that can be brought to full capacity on advance notice limited in time by minutes only.

These items swell the expense of distribution, so that the cost of producing power represents a much smaller percentage of the whole than in plants located elsewhere. Hydro-electric power is less advantageous to the Metropolitan District not only because in New York items other than production cost make such a great proportion of the total cost of delivering current, but also because the source of hydro power is far removed. Being thus removed and not under direct control, it might not be available in time for an emergency peak. Hydro-electric transmission lines to the Metropolitan District varying in length from 100 miles as would be the case from the Delaware River, to 250 miles from the Adirondacks and more than 350 miles from the St. Lawrence and Niagara, present to a manager in the Metropolitan District worries as well as advantages. But duplicate lines and especially lines coming from different directions, the most substantial type of aërial construction that the state of the art will provide, and main trunks with few if any branch connections between points of origin and delivery, will undoubtedly eliminate some of the fears and permit the bringing to New York of hydro-electric power to take a part of the 4,500,000 hp. that must be in operation in this district before 1930. Storage reservoirs whence can be drawn not only the regular supply, but also a temporary excess, would furnish valuable insurance against a failure in coal delivery and present an additional and highly attractive feature. This insurance would offset many of the disadvantages to long-distance transmission. Storage of fuel in New York is possible for a few weeks only. On more than one occasion this city has been dangerously close to a point of actual shutdown due to this failure in delivery. Power thus drawn from storage reservoirs in times of such emergency could be restored by operating the steam plants over longer periods when fuel is available.

Great as are the potential resources of New York in water power, two things are obvious:

1. That in amount they are not in excess of actual requirements.

2. That the objections to long-distance transmission lines will prevent the bringing of the whole of the supply of the Metropolitan District from northern points. The cost of fuel which, although it may fluctuate up and down, nevertheless is bound over a course of years to keep on increasing, raises the question whether the time is not near when some other means of producing power should not be resorted to than by bringing coal in bulk to New York and converting it here into energy. The average freight on coal to New York is now about $3.50 per ton. No matter what may happen to the price of coal at the mine, the cost of transporting coal is not likely to be reduced. If hydro-electric power cannot be obtained in sufficient quantities to carry the burden of the demand for additional power, it is only fair to ask whether the high cost of transportation cannot be reduced. It would certainly seem to be worthy of serious study to see whether it would not be possible to convert coal at the pit-mouth into energy and to transmit that energy by wire to New York.

Burning of Waste Coal

This is not intended as a suggestion for the burning of waste coal in existing refuse piles. There seems to be no evidence that such piles contain sufficient coal fit for burning so as to be a factor in supplying power for New York. If power is to be generated at the mines, recourse must be had to taking the whole of the output of certain mines, converting it into energy in large stations, and then transmitting the energy thus produced.

The possibilities of establishing central stations at the coal mines and the benefits to be derived from inter connection and interchange of power on a large scale are now being investigated by the Superpower Survey of the United States Geological Survey, under the direction of W. S. Murray.

In addition to the direct benefit in lower production cost resulting from hydro-electric development of 1,500,000 continuous horsepower, there is also the great indirect benefit due to the saving of coal. If the production of this amount of power should be generated in economical central stations, the saving in coal would be over 10,000,000 tons per annum; while if it should be generated in isolated plants and locomotives on railways, the saving would be from 40,000,000 to 50,000,000 tons per annum. This saving would tend to preserve our rapidly diminishing coal supply.

The advantages in railway electrification are not confined to the saving in fuel, great as that item will be, but to many items of operation. Were hydro-electric power applied to railways and to industries, even to the extent of New York's potentiality, the railways would be relieved of hauling 40,000,000 tons of freight of the least profitable character. Electric traction simplifies terminal operation, permits longer train runs with consequent fewer division points, eliminates the troubles of water supply and diminishes the number of employees. Therefore, in addition, to the power required for industry and private consumption, there will be, undoubtedly, a large call for central-station power for railway operation.

W. S. Murray's Discussion on Mr. Parson's Paper

We have recently had the opportunity to analyze a large number of power plants with respect to the cost of producing power, varying both in the size of the plant and the capacity factor at which the plant operates. On the basis of 196 power plants in the Superpower Zone burning bituminous coal, I am able to give authentic figures for the cost of producing power.

Comparing a 1,000-kw. plant operating at 15 per cent capacity factor, which is a typical operating condition for industrial plants, a 150,000-kw. plant operating at 45 per cent capacity factor, which is typical of large central-station operation: In the case of the 1,000-kw. plant—with coal at $6 per ton, delivered—the fuel cost amounts to

1.41c. per kw.-hr.; the maintenance 0.36c. and labor and supplies 0.91c., or a total of 2.68c. per kw.-hr. for operating charges. With the 150,000-kw. plant, with the same basic fuel cost per ton, the fuel cost amounts to 0.65c. per kw.-hr.; the maintenance cost 0.07c., and labor and supplies 0.08c., or a total of 0.8c. per kw.-hr. It is further interesting to note in comparing these two costs that the smaller plant uses over twice the amount of coal, five times the amount of maintenance, and eleven and a half times the amount of labor and supplies per kilowatt-hour as does the larger plant. These figures further bring out the fact that there is a saving in fuel cost between the two sizes of plants of about 0.75c. per kw.-hr., compared with 0.72c. saving in maintenance, labor and supplies. In other words, these last items in the cost of power production are very nearly as important as the fuel cost.

The figures given do not take into consideration the fixed charges on the relative costs of the two sizes of plants, which add even a greater burden to the cost of the small-sized plant. Based on estimates recently made, the fixed charges for the small plant would amount to about 3.6c. per kw.-hr. compared with about 1.2c. for the larger plant, making a total cost of power produced of 6.3c. for the small plant as against 2c. for the large plant. In other words, the large central-station plant could produce power for just about one-third of what it could be produced for in the small plant.

Coal in Relation to Operating Charges

Colonel Parsons brings out the importance of the cost of coal in relation to operating charges, and states that the cost of coal is about 75 per cent of the total cost of producing power.

With large plants, operating at high capacity factors, the fuel cost may be more than 75 per cent of the operating charges, but not of the production cost. For instance, in the 150,000-kw. plant, for which I have given costs, you will notice that the fuel cost is 81 per cent of the total operating charge, and about 32 per cent of the total production cost. In industrial plants, small in size and operating at their inherently low capacity factors, the amount of the coal cost is not so great; for instance, in the 1,000-kw. plant, the fuel cost amounted to 52 per cent of the operating charge and 22 per cent of the total production cost.

It is interesting to note with reference to the cost of coal delivered that this averaged in 1919 $5.20 per net ton for New York City. What price may be expected for coal during the period between 1920 and 1930? Based on the opinions of the best authorities whom we could obtain, the indications are that this will increase to about $6.62 for the period we are studying.

Sixteen per cent of our total coal supply lies in the Eastern zone, which is within reasonable freight transportation distance of the Atlantic seaboard, and of all the coal so far mined in the United States 75 per cent of it has been withdrawn from that particular zone. The continuation of this practice points to the increased cost of fuel and the very much more rapid depletion of these particular coal fields.

Water-Power Development

Colonel Parsons has touched upon the possibilities of power from the Delaware River. Here in the East the possibility of water-power development is meager as compared to that in our Western States. Here it has been well, though roughly, stated that we have 30 per cent water power and 70 per cent industry, while in the West there is 30 per cent industry and 70 per cent water power. In these Eastern streams where storage of water is available, remarkable revelations will come to those who study the relation of kilowatt-hours to peaks of varying load factor. The great impounded masses of water behind power and storage dams are nothing but the equivalent of great masses of coal, and if you have not studied it, it will bring amazement to see how, through judicious handling of this impounded water, when utilized under peak loads, its energy in terms of capacity can be made to reach far down toward and in many times touch the base loads of the steam-generating plants operating under high load factor.

When the dam and headworks and land damage have been paid for, the additional cost of an installed kilowatt in generating capacity is far less for a water-power plant than for a steel plant. In 1930 water power available in the superpower zone will represent but 10 per cent of the total demand of this zone, but we must not fail to realize what an important part it can play in its economic relation to capacity-demand.

The Delaware River, with its possibility of large storage reservoir, presents an unusually good opportunity of development upon a peak-load basis, which will make it very much more valuable to the region than were it developed on a base-load basis.

Colonel Parsons's frequency figures show great predominance of 25 cycles for the Metropolitan District, but the tendency toward and frequency in the total superpower region is very strongly towards 60 cycles. An analysis of the sales of generating equipment in the district, made by one manufacturer, shows an increase in the last six years of 340 per cent in 60-cycle equipment, and a decrease of 60 per cent for 25 cycles.

Generating Power at the Mines

In generating power at the mines it must be ascertained that sufficient coal may be obtained at a reasonable price or cost during the life of the plant. For instance, in the anthracite region the culm banks could be relied upon but for a very short period of time, and then we would have to turn to the smaller of the steam sizes of freshly mined coal. It is impossible of course to take the coal required by exceedingly large base-load steam-electric plants in the anthracite region from a certain few mines, because the amount of coal of the small steam sizes—that is, No. 3 buckwheat and smaller—is a relatively small percentage of the total, and amounted in 1919 to only 5.5 per cent of the total amount of coal shipped. The coal for these large plants would accordingly have to be gathered from a large number of mines.

The location of generating plants at the mouth of mines is dependent upon transportation rates, sufficiency of coal and water supply and the price of coal at the mine and—most important of all—the constancy of these three important considerations. There is, of course, the possibility, through the complete electrification of the mines, of releasing some six million tons a year for use in power plants in the mining region. The power plant located at the mine fundamentally must be a base-load plant operating at very high capacity, as otherwise the cost of transmission would make the plan a financial failure.

While an immense amount of research work has been done and is being done in the endeavor to discover some agency for the storage of electrical energy, there is today nothing in sight that even looks promising. The next step to obtain the lowest cost is to create a tremendous power reservoir, such as is proposed by the Superpower System, into which the base load, steam-electric plants, and the peak load hydro-electric plants can put their power, and from which it can be tapped when and where needed. The very existence of such a power reservoir does more to permit the economical delivery of power than do all of the economies that can be practiced within the plants themselves. The creation of such a reservoir provides a great clearing house through which the customer may receive maximum power at minimum cost.

A world exposition is being planned for 1926 in commemoration of the 150th anniversary of American Independence. The movement at present centers in Philadelphia, where it is expected the fair will be held. Mayor Moore, of that city, recently appointed a committee of 100 to prepare suitable plans and since then has requested councils to appropriate $50,000 to provide for the expenses of the big exposition.

Sweden imported over 1,000,000 tons of American coal during the first nine months of 1920. This was ten times the amount imported in the whole year of 1919.

Federated American Engineering Societies Meets at Syracuse

At a meeting of American Engineering Council in Syracuse, N. Y. on Monday, Feb. 14, Lawrence Wilkerson Wallace was unanimously elected secretary of the Federated Societies. Mr. Wallace was born in Austin, Texas, in 1881 and graduated from the Agricultural and Mechanical College of Texas in 1903 with the degree of S. B., later taking the degree of M. E. at Purdue University, on the faculty of which in 1906 he became head of the Department of Railway and Industrial Management.

Since leaving Purdue, he has been active in engineering lines connected with railway and factory management and

L. W. WALLACE

has written a number of technical books on engineering subjects. He was for some time connected with the Diamond Chain and Manufacturing Co., of Indianapolis, in high executive positions and is a member of numerous engineering organizations, having served three terms as president of the Society of Industrial Engineers, and been president of the Indiana Engineering Society. In the Federated American Engineering Societies he has served as vice chairman of the Committee on the Elimination of Waste in Industry, and his election as secretary of the organization is a most appropriate one.

Besides taking action on various committee activities, the council decided to recommend to President Harding that an engineer be appointed Assistant Secretary of War, and accepted an invitation from Philadelphia engineers to hold the April meeting in that city. The June meeting will be held in St. Louis.

At a joint dinner of the National Councils of the American Federated Engineering Societies, American Society of Mechanical Engineers and Technology Club, given at the Hotel Onondaga, E. D. Newkirk, president of the Technology Club, presented Judge Frank H. Hiscock as presiding officer and Mr. Hoover was the principal speaker. The latter said in part:

The Federation of Engineering Societies has organized a preliminary survey which will attempt to visualize the nation as a single industrial organism and to examine its efficiency toward its only real objective—the maximum production. In a general way this inquiry will bear upon the whole question of deficiency in production—industrial waste in a broad sense.

The waste in our production is measured by the unemployment, the lost time due to labor conflict, the losses in labor turnover, the failure to secure maximum production of the individual, due either to misfit or lack of interest. Beyond this again is a wide area of waste in the poor coordination of great industries, the failures in transportation, coal and power supplies.

The greatest area of waste lies in the large periods of slack production and unemployment, due to the ebb and flow of economic tides between booms and slumps. The ideal would be steadily increasing production, an ideal of no likelihood of exact realization because of inability to gage the advance in growth consumption or the approach of saturation.

Another variety of intermittent employment, and thus great waste, lies in certain industries now operating upon an unnecessarily wide seasonal fluctuation, as for instance the bituminous-coal industry. This is today one of our worst functioning industries. The mining engineers have already pointed out the directinos in which remedy lies, through storage, through railway rate differentials and other remedies. Through constructive action an army of men could be released from this industry of necessity to convert some luxury into a necessity of tomorrow.

The second largest area of waste in productivity is the eternal amount of labor friction, strikes and lockouts. The varied social and economic forces involved in this problem need no repetition here. The growth of industry into large units has destroyed the old mutuality of interest between employee and employer. Our repetitive processes have tended to destroy the creative instinct and interest in employees; at times their efforts sink to low levels indeed. We will yet have to reorganize the whole employment relationship to find its solution. There is great promise in this field during the past two years, and the progress in this matter is one of the subjects under our inquiry.

Another type of waste lies in our failure to advance our industrial equipment. The Superpower Board will demonstrate the saving of 25,000,000 to 50,000,000 tons of coal annually by the electrification of our Eastern power supply. The St. Lawrence Waterway Commission will demonstrate the saving of five to ten cents a bushel to the farmers of fifteen states by unlocking the lakes to ocean-going vessels. Nor will this added efficiency to our national transport injure our present systems of canals and waterways, for we have ever found that the prosperity of an industry blesses them all.

Nor do we believe it is necessary to effect these things by the Government. The spirit of co-operation that has been growing in our country during the last thirty years has already solved many things; it has standardized some things and is ripe for initiative toward co-operation of a wide-spread character. The leadership of our Federal Government in bringing together the forces is needed. No greater field of service exists than the stimulation of such co-operation. The first step is sane analysis of weakness and sober proposal of remedy. If the facts can be established to an intelligent people such as ours, action is certain even if it be slow. Our engineers are in an unique position for this service, and it is your obligation to carry it forward.

During the meeting Mr. Hoover announced the names of fifteen well-known engineers and business men as the permanent committee to carry out the work outlined, "marking the beginning of what is officially styled a great national assay of waste, in which from 100,000 to 200,000 engineers functioning through the council will attempt by studying the nation as a single industrial organism to locate the weaknesses in the country's production system."

The New York Building Superintendents' Association held its first banquet, entertainment and ball at the Waldorf-Astoria on Feb. 11. The main ballroom was prettily decorated with American flags in tasteful designs. Fully 700 partook of the banquet, and the entertainment and ball was enjoyed by more than 1,000 members and guests. The several committees are to be complimented on the success of the initial event of the organization. The membership has nearly reached the 400 mark. The officers are: F. W. Douglas, president; E. H. Hazen, vice president; R. Byron, secretary; K. H. Muller, treasurer.

The production of electricity by public utility power plants in the United States for the first ten months of 1920 was 36,487,469,000 kw.-hrs., of which 22,801,675,000 kw.-hrs. was produced by fuels and 13,685,794,000 kw.-hrs. was produced by water-power.

The Egyptians are becoming modern; they imported more than a million dollars worth of stationary internal-combustion engines in the first nine months of 1920, and in the first eight months, $215,905 worth of electric-light bulbs.

Problems in Station Design

In a paper on "The Design of Steam Power Stations," presented before the Franklin Institute, of Philadelphia, Feb. 10, Frank S. Clark, mechanical engineer, of Stone & Webster, discussed the fundamental considerations necessary to the laying out of a power station.

After having determined upon the site, with reference to availability of condensing water, coal-receiving facilities, soil suitable for foundations, etc., it is necessary to decide upon the size of units to be installed. In doing this, one should start with the load curve of the community, together with the load factor and probable growth in load, the latter being most important in determining the size of units. The load factor is in itself not complete without the load curves from which it has been determined. The unit design is usually most desirable, and it is, as a general thing, unwise to have the investment cover more than the initial requirements. The design, however, should provide for extension, and in certain particulars such as steel work, should take into consideration the probable substitution of new types of apparatus during the life of the station. Length of services at a given load factor is also important, inasmuch as the substitution of larger and newer units usually tends to lower the load factor at first. A high load factor generally warrants large units.

The speaker then took up in detail the various component parts of a power station, commenting upon present tendencies in design, and was of the opinion that the practical limit in turbine capacities had about been reached; also that the near future would not see any radical attempt on higher steam temperatures, 650 deg. being a conservative figure for economy and operating satisfaction. In the layout of boiler rooms present practice seems to favor the coal larry, rather than the individual spouts, as the former has the advantage of making available the whole bunker storage for any boiler and provides greater accessibility to the boiler fronts. In some of the new stations much attention is being given to recirculation of the air and to methods of preventing roof condensation in the turbine room.

Another prevailing practice is to cut away the turbine-room floor as much as possible, so as to leave open the space to the condenser for better light and accessibility, especially with reference to the traveling crane.

Mr. Clark showed, on the screen, designs of a number of the latest stations and compared their layouts.

Proposed Massachusetts Law Denounced

Vigorous opposition is being made by the Brotherhood of Power Workers of Massachusetts to Senate Bill No. 247, which is to be heard at the State House in Boston before the Committee on Mercantile Affairs on March 1. The organization is sending out an urgent call for support in its fight against the proposed law and requests everyone who wants Massachusetts power plants to be safely operated to instruct his State Senator and the Representative of his district to oppose the passage of this bill.

The Brotherhood denounces the measure as a reactionary and dangerous legislative blunder, which would, if passed, result in grave danger to life and property through the employment of inexperienced, incompetent help in power plants, with consequent liability of explosions, and which would therefore create anew the unsafe conditions that originally caused the adoption of the boiler and license law.

The *Journal of Electricity* has changed its editorial scope from the general subject of electricity to that of Western industrial development and its name to *Journal of Electricity and Western Industry.*

It is aimed to make the paper a sort of "Chamber of Commerce of the West" which will record and encourage the progress of the far West, not simply in the electrical industry, but also in all industries dependent upon electricity. The *Journal of Electricity and Western Industry* will pay especial attention to the big Western water-power projects in an effort to bring home to the average, non-technical business man the tremendous importance of these developments.

Washington News

Superpower Progress—Disagreement Over Water-Power Act—Great Falls Development Urged

By Paul Wooten
Washington Correspondent

The advisory board of the Superpower Survey met on Feb. 18 with Judge John Barton Payne, the Secretary of the Interior. The session was devoted to a discussion of the corporate and financial structure necessary to put the engineering project of the Survey into effect. The advisory board is interested chiefly in the relation of the Superpower plan to the old program, the rate of replacement of old units with new, the incentives that may induce interconnection of existing systems and above all the safeguarding of the public interests without discouraging private initiative.

George Otis Smith, Director of the Geological Survey, promised that the engineering report will be submitted promptly on June 30, the date on which it is due. He pointed out that though less than two-thirds of the time allotted to the investigation has passed, tentative conclusions on a number of phases of the problem are already apparent. Some of these conclusions concern the ratio of both operating and production cost in large and small power units, the measure of fuel saving possible in central-station operation and the relative operating economy of the electric versus the steam locomotive. It has been established that the density of traffic on the railroads in the Boston-Washington area is insufficient to justify electrification except on some 6,000 miles of the 36,000 miles of railroad in that region.

Discussion of Water Power Act

The remainder of the major regulations covering the administrative features of the Water-Power Act will be promulgated before the end of February. The draft of these regulations was taken up for discussion last week by officials of the Federal Power Commission and representatives of the outside interests concerned. A great many changes in the draft were suggested in conferences lasting two days. Finally, it became evident that no agreement could be reached immediately, and it was decided to allow the matter to go over for a week.

The National Electric Light Association took exception particularly to the draft of the regulation with regard to depreciation reserves and the establishment of a system of accounting, but when the Commission took up these questions at its Feb. 14 meeting, it approved the view of its chief accountant that it should set up and maintain regular depreciation reserves and establish a uniform system of accounting.

Great Falls Power Development

The Federal Power Commission has sent a communication to the President of the Senate and to the Speaker of the House of Representatives recommending that the work on the development of power at Great Falls, on the Potomac, be undertaken at once in accordance with the report made by Major Max Tyler, Corps of Engineers, U. S. A. The communication says:

Our study of the situation satisfies us that all the power so developed will find a ready market in the District of Columbia and the circumjacent territory to which it can be transmitted without disproportionate line loss or distribution system cost.

The plan for the development of hydro-electric power from the Potomac has three great advantages: (1) It contemplates a serial development of which the several elements can be separately and consecutively undertaken, with the result that the power resources of the District will be augmented from time to time as the capacity of the District for the absorption of the power developed increases; (2) the suggested conservation of use of existing steam installations for the production of power makes it highly improbable that any substantial loss will accrue to those who have invested in steam-power plants; and (3) the serial development of water power will render unnecessary extensive and costly additional steam power-plant installations, which would be necessary unless existing power producing facilities are supplemented as here suggested by the early development of a large body of primary power from a dam erected near Chain Bridge.

New Publications

THE SLIDE RULE. By C. N. Pickworth. Seventeenth edition. Published by the D. Van Nostrand Co., 8 Warren St., New York City. Cloth, 7 x 5 in.; 133 pages; 39 illustrations. Price, $1.50.

This volume is a practical manual covering the principles, construction and method of use of most of the slide rules on the market. It is written in a not too technical manner, contains numerous tables and mathematical data, and the present edition describes some late designs in slide rules and contains some revisions over previous issues. It should be of interest to beginners in the art of slide-rule manipulation and to engineers who have occasion to use the instrument extensively in computation.

BOILER PERFORMANCE

Brownlie & Green, Ltd., 2 Austin Friars, E. C. 2, England, are distributing a small booklet, reprinted from "Engineering," by David Brownlie on "Average Figures for the Performance of Some Different Types of Steam Boilers."

Personals

G. C. Derry, district manager of power apparatus in the New York office of the B. F. Sturtevant Co., has been appointed manager of the fuel economizer and mechanical draft departments of the company and is now at its factory in Readville, Mass.

Alexander England, a veteran of the Westinghouse Air Brake Co. and assistant chief engineer since 1914, has been appointed chief engineer to succeed Samuel W. Dudley, who has taken a professorship at Yale.

Society Affairs

Akron Section, A. S. M. E., will meet Feb. 25 to hear C. Harold Berry speak on "The Heat Balance of a Turbine."

Cleveland Section, A. S. M. E., will meet March 1 to hear a talk on "Power-Plant Evolution," by C. F. Hirschfeld.

Philadelphia Section A. S. M. E., will be addressed Feb. 28 by Dean Dexter S. Kimball of Cornell, on "A Broader Field for the Engineer."

New York Section, A. I. E. E., will meet Feb. 25 to hear a lecture on the "Habits of the Electron," by Dr. Saul Bushman, of the General Electric Co.'s research laboratory.

The National Efficiency Society, in connection with its ninth annual meeting, will hold a conference on "Industrial Peace and Democracy" at the Hotel Astor, New York City, on Feb. 26 throughout the day, concluding with a dinner at 7 p. m. The society's object is the improvement of industrial relations all over the world.

Business Items

The Key Boiler Equipment Co. has moved its general offices to 27th and McCausland Ave., East St. Louis, Ill.

John Mohr & Sons have consolidated their Chicago and South Chicago works with general offices at 96th St. and Calumet River, South Chicago.

The Duplex Engine Governor Co., Inc., Brooklyn, N. Y., has made C. F. Guttzeit purchasing agent in place of S. T. Thompson, who has been appointed director of sales.

The Crocker-Wheeler Co. has moved its Philadelphia office from the North American Building to 1209 Arch St. The Philadelphia office has been under the charge of Samuel Russell, Jr., since 1897.

William W. Nugent & Co., Inc., manufacturers of oil filters, oiling and filtering systems, have secured the Catton, Neills & Co., of Honolulu, as their representatives in the Hawaiian and Philippine Islands.

Elliott Co., manufacturer of power accessories, has made some changes in its sales organization. James E. Watson, formerly sales manager, has taken up the duties of general manager; C. L. Brown, for many years district manager of the Chicago office, is now general sales manager, and W. W. Turner, who has been connected with the Chicago district office, succeeds Mr. Brown as Chicago district manager.

Trade Catalogs

The Alberger Heater Co., Buffalo, N. Y., is distributing a 7½ x 11 in., 48-page catalog describing its line of heaters, interchangers, coolers, condensers and other heat transmission equipment.

The American District Steam Co., North Tonawanda, N. Y., has issued three bulletins, Nos. 151, 152 and 153, describing "ADSCO" water heaters, angle fittings and rotometers, or portable condensation meters.

Frank D. Chase, Inc., Chicago, has issued a 5 x 8-in. booklet, "Factories That Fit," consisting principally of photographs of plants designed by them and setting forth their idea of planning factories to suit the work that is to be done in them in order to reduce handling costs.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoted	Feb. 8, 1921	Feb. 15, 1921
Pocahontas,	Columbus	$4.00	$3.75@4.00
Clearfield,	Boston	2.75	2.15@3.00
Somerset,	Boston	3.40	2.50@3.75
Pittsburgh,	Pittsburgh	2.50	2.25@2.50
Kanawha,	Columbus	2.40	2.50
Hocking,	Columbus	2.35	2.25@2.50
Pittsburgh,	Cleveland	2.50	2.25@2.75
Franklin, Ill.,	Chicago	2.75	2.25@3.25
Central, Ill.,	Chicago	2.15	1.50@2.25
Ind. 4th vein,	Chicago	2.20	1.85@2.50
Standard,	St. Louis	2.00	1.90@2.00
West Ky.,	Louisville	2.55	2.10@2.50
Big Seam,	Birmingham	2.95	2.95@3.25
S. E. Ky.,	Louisville	2.70	2.50@2.75

DIESEL FUEL OIL

Chicago—24@28 deg. Baumé, $1.10@$1.20 per bbl.; 32@34 deg., 3¾@4¼ c. per gal.

Cincinnati—In 8,000-gal. tank cars; 26@28 deg., 9¾ c. per gal., 30@34 deg., 10c.

Cleveland—24@30 deg. fuel oil, group 3, $0.85 per bbl.; gas oil, group 3, 4c. per gal. No market for boiler oil.

Philadelphia—26@28 deg. fuel oil, 8½c. per gal.; 30@34 deg. gas oil, 10½c.; 16@20 deg. boiler oil, 6c.

St. Louis—Base plus freight; group 3 24@26 deg., $1.10@$1.25 per bbl.; 26@28 deg., $1.20@$1.35; 28@30 deg., $1.30@$1.45; 30@32 deg.,$1.40@$1.55; 32@34 deg., $1.50@$1.65. No market for 16@20 deg. Baumé boiler oil.

New Construction

PROPOSED WORK

Mass., Danvers Junction (Danvers P. O.)—H. P. Gifford, c/o Salem Five Cents Savings Bank, plans to build a cold storage plant.

Mass., Falmouth—The Memorial Bldg. Com. plans to build a town hall. About $250,000.

Mass., Worcester—The city Bd. Educ. plans to build a 3 story high school. About $1,000,000. Architect not selected.

R. I., Providence—The State plans to build an addition to the Capitol including a steam-heating system. About $3,000,000. McKim, Mead & White, 101 Park Ave., New York City, Engrs. and Archts.

Conn., Bristol—The Connecticut Military Emergency Bd., State Armory, Hartford, has petitioned the State Legislature for $250,000 to construct an armory here. Architect not selected.

Conn., Danbury—The Bd. Educ. plans to build a school. About $600,000. Architect not selected.

Conn., Hartford—The 2nd North School Dist. plans to build a school. About $950,000. Architect not selected.

Conn., Middletown — The Connecticut State Hospital for the Insane, c/o State Controller, Hartford, plans to build a hospital, etc., at South Farms. About $545,000.

Conn., New Haven—The Knights of Columbus, 956 Chapel St., will receive bids about March 10, for a 4 story, 100 x 140 ft. association building including a steam heating system on Wall and Church Sts. About $500,000. W. J. Guggolu, Liberty Bldg., Archt.

Conn., Waterbury—L. A. Walsh, Archt., 51 Leavenworth St., will receive bids about March 1 for a 5 story, 55 x 132 ft. hospital addition on Franklin and Union Sts., for St. Marys Hospital, Franklin St. About $500,000.

N. Y., Astoria (Long Island City P. O.)—The Bd. Educ., 500 Park Ave., New York City, plans to build a school including a steam heating system on 15th and Grand Aves. About $904,000. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., Brooklyn—The Bd. of Educ., 500 Park Ave., plans to build an addition to P. S. 26 on Quincy St., near Reid Ave. including a steam heating system. About $400,000. C. B. J. Snyder, Municipal Bldg., New York City, Engr. and Archt.

N. Y., Flushing, L. I.—The Joint Ownership Constr. Co., 7 East 42nd St., New York City, will build a 5 story, apartment house including a steam heating system on Bowne Ave. About $400,000. A. J. Thomas, 137 East 45th St., New York City, Archt. and Engr.

N. Y., Glen Island (New Rochelle P. O.)—A syndicate, c/o H. J. Hardenberg, Archt. and Engr., 47 West 34th St., New York City, is having plans prepared for a hotel including a steam heating system. About $1,000,000.

N. Y., Jamaica, L. I.—The Bank of the Manhattan Co., 40 Wall St., New York City, is having plans prepared for a bank building including a steam heating system on Union Hill Ave. About $700,000 M. Smith, Far Rockaway, L. I., Archt. and Engr.

N. Y., Long Island City—The Dept. of Educ., 500 Park Ave., New York City, plans to build a school on Polk Ave. between 21st and 22nd St. including a steam heating system. About $800,000. C. B. J. Snyder, Municipal Bldg., New York City, Engr. and Archt.

N. Y., Lyons—The Bd. of Educ. plans to build a High School to replace the one recently destroyed by fire. About $300,000.

N. Y., Newtown (Flushing P. O.)—The Bd. of Educ., 500 Park Ave., New York City, plans to build a school including steam heating system. About $900,000. C. B. J. Snyder, 28th Floor Municipal Bldg., New York City, Engr. and Archt.

N. Y., New York—C. K. Eagle, head of syndicate, c/o C. W. Buckman, 175 5th Ave., plans to build an apartment house including a steam heating system on Central Park South. About $2,000,000.

N. Y., Tupper Lake—J. A. Villnave & Son is in the market for a 35 hp. boiler and engine and one lave saw mill or equal.

N. J., Jersey City—J. M. Brennen, Morris & Shessings, Broad St. Theatre, Newark, and J. LeBlang, 1482 Bway., New York City, plan to build a 2 story theatre, store and office building including a steam heating system on Newark and Summit Aves. About $500,000. W. E. Lehman & Co., 738 Broad St., Newark, Archt. and Engr.

N. J., Newark—The Bd. Educ., Broad St., plans to build an addition to its school, including a steam heating system on Abington Ave. About $350,000. Architect not selected.

N. J., Newark—The Bd. Educ., City Hall, Broad St., will soon re-advertise for bids for crippled children's school including a steam heating system on Ridge St. About $270,000. J. H. Ely, Broad & Market Sts., Archt., and Engr.

N. J., Nutley—The Dept. of Educ. plans to build a High School including a steam heating system. About $400,000. Starrett & Van Vleck, 8 West 40th St., New York City, Engrs. and Archts.

Pa., Philadelphia—The Bureau of Water Supply, City Hall, will receive bids until Feb. 24, for furnishing boilers for Queens Lane, etc.

Pa., Philadelphia—The City Transit, 1211 Chestnut St., will receive bids until Feb. 23 for installing an electric conduit system in station building, etc.

Pa., Philadelphia—The city plans to build a town hall including a steam heating system on Germantown Ave. and Haines St. About $400,000.

Pa., Pittsburgh—The Crane Co., South Michigan Ave., Chicago, Ill., is having plans prepared for a 6 story, 72 x 92 ft. warehouse and a 2, and 3 story, 192 x 290 ft. pipe shop on 24th St. Cost between $500,000 and $600,000. Hunting Davis Co., Century Bldg., Archts.

N. C., Benson—The city sold $30,000 bonds for an electric light system.

N. C., Dunn—The town plans to improve and enlarge the power plant. About $100,000. T. L. Riddle, Chamber of Commerce, Secy.

N. C., Greensboro—The city plans to build a substation power line and change pumping station from steam driven to electrical. Cost to exceed $100,000. R. H. Milton, Engr.

S. C., Greenville—The Greenville Marble & Granite Co. is in the market for engines and motors. S. P. Warnock, Purch. Agt.

Fla., Ocala—The city plans to install a turbine unit in the electric light plant.

O., Cincinnati—New Longview Hospital Bldg. Comn., C. M. Dean, Secy., will receive bids until Feb. 23 for a 2 story, 150 x 300 ft. hospital including heating and ventilating systems on Paddock Rd. About $449,000. Elzner & Anderson, Citizens Natl. Bank Bldg., Engrs. and Archts.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., is having plans prepared for a 2 story annex to the Glenville school including a steam heating system. About $400,000. W. R. McCormack, Archt.

O., Cleveland—The city received bids for installing a heating and ventilating system in the public hall at East 6th St. and St. Clair Ave., from J. C. Boehm Co., 1555 Hamilton Ave., $249,500; Chappell Warren Co., 1836 St. Clair Ave., $252,994.

O., Cleveland—The Cleveland Grays Armory, Captain H. P. Shippe, 2840 Carnegie Ave., plans to rebuild the 1 story, 100 x 300 ft. armory which was recently destroyed by fire. About $300,000.

O., Cleveland—The Hinkel Auditorium Co., c/o M. Hinkel, 6521 Carnegie Ave., plans to build a 6 story, 200 x 400 ft. auditorium and office building. About $1,000,000.

O., Cleveland—The Merrill System Co., c/o H. E. Durbin, 10600 Euclid Ave., plans to build a 4 story apartment house on Derbyshire Rd. About $250,000.

O., Columbus—The Bd. of Educ., Town and High Sts., plans to build a High School on East Bryden Rd. About $1,000,000. Howell & Thomas, 203 Euclid St., Cleveland, Archt.

O., Columbus—The Bd. of Educ., Town and High Sts., plans to build a High School on South High St. About $1,000,000. Richards, McCarty & Bulford, East Broad St., Archt.

Ind., Whiting—N. S. Spencer & Sons, Archts., 37 West Van Buren St., Chicago, Ill., will receive bids until March 15 for a school here, including a steam heating system for the Bd. Educ. About $500,000.

Mich., Detroit—The Capitol Theatre Co. will soon award the contract for a 3 story theatre. About $500,000 C. Howard Crane, Huron Bldg., Archt.

Mich., Detroit—The Dept. of Purchases and Supplies, 710 Marquette Bldg., is in the market for 3 reciprocating grinders and 4 gasoline driven arc welding generators with all welding accessories. G. J. Finn, Purch. Agt.

Mich., Detroit—The Masonic Temple Association, Lafayette Blvd. and 1st St., plans to build an 8 story, 50 x 190 ft. club house including a steam heating equipment, on Temple Ave. G. D. Mason & Co., 80 Griswold St., Archt.

Mich., Grosse Pointe Park (Detroit P. O.)—The Bd. of Educ., plans to build a 2 story school including steam heating system. About $250,000. C. J. Haas, Kresge Bldg., Detroit, Archt.

Ill., Chicago—The Woodlawn Amusement Co., c/o Ralph C. Harris, Archt., 190 North State St., will receive bids until Feb. 20 for an amusement park to include about 30 buildings on Milwaukee and Devons Aves. About $500,000.

Ill., Freeburg—The city is having preliminary plans prepared for a lighting plant. About $30,000. Fuller & Beard, Chemical Bldg., St. Louis, Mo., Engrs.

Wis., Appleton—V. J. Klutho, Archt., Chemical Bldg., St. Louis, Mo., will receive bids about June 1 for a 5 story, 100 x 300 ft. hospital including a steam heating system for the St. Elizabeth Hospital Association. About $1,000,000.

Wis., Kenosha—The Bd. Educ. plans an election to vote on $500,000 for the construction of two junior high schools. J. Glerum, 369 Park St., Pres. Architect not selected.

Wis., Kenosha—The Collins Theatre Enterprises, c/o Burke Theatre, is having preliminary plans prepared for a 2 story theatre. About $275,000. J. H. Pridmore, 38 South Dearborn St., Chicago, Archt.

Wis., Milwaukee—Cahill & Douglas, Engrs., 217 West Water St., will receive bids about Feb. 20 for the installation of one 72 in. x 18 ft. power boiler for the Milwaukee Bridge Co., 1400 33rd St.

Wis., Owen—Clark Co. will receive bids until March 1 for the superstructure of a 2 and 3 story, 46 x 200 ft. asylum near here. About $365,000. Claude & Starck, Badger Annex, Madison, Wis., Archts.

Wis., Racine—The Bd. Educ. will receive bids until March 3 for a 3 story, 134 x 235 ft. addition to the Washington School. About $350,000. E. B. Funston Co., Robinson Blk., Archt. Noted Oct. 5, 1920.

Wis., Racine—The Racine Memorial Association, c/o W. Hight, 305 6th St., is having preliminary plans prepared for a 2 story memorial building. About $300,000. A. A. Guilbert, Robinson Blk., Archt.

Wis., Sheboygan—The Bd. Educ., 808 North St., will soon receive bids for a 2 story, 268 x 334 ft. high school inluding a steam heating system on 9th and Jefferson Sts. About $900,000. T. Benfey, Secy., Childs & Smith, 64 East Van Buren St., Chicago, Archts.

Wis., St. Francis (Milwaukee P. O.)—The St. Francis Seminary plans to build a seminary. About $2,000,000. Architect not selected.

Minn., Minneapolis—The Bd. of Trustees of Asbury Hospital, 914 Elliott Ave., plan to build a 3 story reinforced concrete addition, to serve as nurses' home and auxiliary unit in emergency. A steam heating system will be installed. About $250,000. F. A. Chamberlain, Pres.

Minn., Nashwauk—The City Council plans an election, to vote on $150,000 bonds for a water and light plant, etc.

S. D., Watertown—The Bd. Educ. is having plans prepared for a 3 story, 152 x 178 ft. high school including a steam heating system. About $250,000. C. L. Pillsbury Co., 1206 2nd Ave., South, Minneapolis, Minn., Engr. Tyrie & Chapman, 1206 2nd Ave., S., Minneapolis, Minn., Archts. Noted Dec. 28, 1920.

Mo., Chaminade (St. Louis P. O.)—V. J. Kluto, Archt., Chemical Bldg., St. Louis, will receive bids until April 1 for a 5 story, 161 x 168 ft. school including a steam heating system, for the Society of Mary. About $350,000.

Mo., Eminence—The Western Tie & Timber Co., Syndicate Trust Bldg., St. Louis, plans to build a hydro electric plant, etc. W. Poleman, Pres. C. G. Graeter, Engr.

Kan., Wichita—The Orpheum Theatre Co. plans to build a 6 story, 140 x 150 ft. theatre at 1st St. and Lawrence Ave. About $700,000. J. Eberson, 64 East Van Buren St., Chicago, Ill., Archt.

Mo., St. Louis—The Liberty Central Trust Co. will receive bids about April 1 for a 3 story, 41 x 128 ft. bank on Broadway and Olive St. A steam heating system will be included. About $300,000. G. F. A. Brueggeman, Third Natl. Bank Bldg., Archt.

Mo., St. Louis—A syndicate, c/o H. M. E. Pasmezoglu, 4940 McPherson Ave., is having preliminary plans prepared for a 4 or 5 story, 150 x 175 ft. theatre and apartment building including a steam heating system on Delmar and Aubert Sts. About $1,200,000. Mauren, Russel and Crowell, Chemical Bldg., Archts.

Mo., Warrenburg — The city plans an electin to vote on $150,000 bonds for a power plant. F. L. Wilcox, Chemical Bldg., St. Louis, Engr.

Tex., Spur—Grogan & Stovall, Vernon, plans to build a power house and install generating machinery in same.

Col., Colorado Springs—The city plans to build a 3 story auditorium. About $600,000.

Wash., Seattle—F. A. Naramore, Archt., will soon receive bids for a high school to be known as the Roosevelt High School, for School Dist. N. 1. About $1,000,000.

Cal., San Bernardino—The Sante Fe R.R. Co., Kerckhoff Bldg., Los Angeles, plans to build a 70 x 510 ft. addition to its machine shop and an 80 x 300 ft. blacksmith shop and install new transfer table, traveling cranes, etc. About $500,000.

Ont., Alvinston—The Town Council is having plans prepared for a hydro electric system and is in the market for equipment. About $16,000. J. Irving, Engr.

Ont., London—E. V. Buchanan, c/o Utilities Bd., is in the market for an electrically driven turbine pump of 1,000,000 gal. capacity and one of 3,000,000 gal. capacity; first to operate under 150 lbs. and the second under 20 lbs.

Ont., Ottawa—The Ottawa Collegiate Inst. Bd., Lisgar St., is having plans prepared for a high school in the Glebe. About $300,000. J. A. Ewart, Jackson Bldg., Bank St., Archt.

Ont., Toronto—The Canadian Libbey Owens Sheet Glass Co., 241 Spadina Ave., Toronto, is in the market for 2 machine motors, 2 turbo generators, 2 centrifugal compressors, 3 turbo blast fans, 1 electric crane, box shop machines, machine shop tools, conveyors, piping, wind piping sprinklers and pyrometers.

CONTRACTS AWARDED

Pa., Philadelphia—W. Fox, 58th St. and 10th Ave., will build a theatre and office building including a steam heating system on 16th St. About $1,000,000. Work will be done by day labor.

N. Y., White Plains—Bloomingdale Hospital, North St., has awarded the contract for a nurses home, to M. Reed & Co., 114 West 39th St., New York City. About $400,000.

O., Cleveland—The city has awarded the contract for furnishing transformers for light plant, to the Kuhlman Electric Co., at $60,154.

Cal., Glendale—The city has awarded the contract for an electrically operated pumping plant, to J. C. Bannister, 903 North Mariposa Ave., Los Angeles, at $19,446. A centrifugal pump and 60 hp. motor will be installed in same.

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